SER. II, VOL. 23 *May 1961* NO. 7

TRANSACTIONS OF THE NEW YORK ACADEMY OF SCIENCES

Managing Editor
EDGAR W. WHITE

Editor
FRANKLIN N. FURNESS

CONTENTS

Mineralogy and Petrology of the Green River Formation of Wyoming, Utah, and Colorado. *By* CHARLES MILTON 561
Tetrahydro-1,3-Benzodiazepine: A New Heterocyclic System. *By* GEORGE DESTEVENS AND MARYLOU DUGHI 568
A Nonlinear Model for a Computer-Assisted Medical Diagnostic Procedure. *By* T. T. TANIMOTO 576
Basic Mechanisms of Pupillary Movements. *By* OTTO LOWENSTEIN AND IRENE E. LOEWENFELD 579
Evaluation of Candidates for the Professions. *By* WIMBURN L. WALLACE 587
Exciton Spectra and Their Magneto Optical Effects. *By* R. G. WHEELER AND J. O. DIMMOCK 593
Field Studies on Sandfly Fever and Kala-Azar in Pakistan, in Iran, and in Baltistan (Little Tibet), Kashmir. *By* HERBERT C. BARNETT AND WILLIAM SUYEMOTO 609
A Re-examination of Northwest Coast Economic Systems. *By* ANDREW P. VAYDA 618
Future Sources of Drinking Water. *By* JOHN W. COLTON 625
Conferences Held 636
New Members 641

Copyright, 1961, by The New York Academy of Sciences

Transactions of The New York Academy of Sciences, Series II, Volume 23, No. 7
May 1961

Second-class postage paid at New York, N.Y. This publication is distributed to members and is published monthly from November to June inclusive, by The New York Academy of Sciences, 2 East Sixty-Third Street, New York 21, N.Y.

Executive Director: EUNICE THOMAS MINER

SECTION OF GEOLOGICAL SCIENCES

MINERALOGY AND PETROLOGY OF THE GREEN RIVER FORMATION OF WYOMING, UTAH, AND COLORADO*

Charles Milton

United States Geological Survey, Washington, D.C.

The Green River formation is present in four great basins as a series of Eocene lacustrine and fluviatile beds, as much as 1000m. or more in thickness. The classical monograph of W.H. Bradley (1931) *Origin and Microfossils of the Oil Shale of the Green River formation of Colorado and Utah* described in detail the oil shales that constitute much of the lacustrine beds: containing a remarkable flora and fauna. Bradley described the extraordinary beds of analcite so widespread in the Green River formation, as well as deposits of sepiolite, calcite, dolomite, pyrite, and quartz. He called attention to peculiar salt-crystal cavities suggestive of former anhydrite or possible glauberite. The nature of the mineral that once filled these molds remained a mystery until 1947, when T. Ertl (1947) identified nahcolite, $NaHCO_3$, in the Green River formation in Utah. Meanwhile, in 1939, J. J. Fahey had begun a study of a wildcat oil-well core from Green River, Wyo. For hundreds of meters this core contained innumerable beautiful crystals of a strange new mineral that Fahey showed to be a new species, shortite, $Na_2Ca_2(CO_3)_3$ (FIGURE 1). Continuing his study of this core, he found a second new mineral, loughlinite, $H_{16}Na_2Mg_3Si_6O_{24}$, essentially a fibrous sodium sepiolite. A third remarkable discovery in this core was bradleyite, $Na_3PO_4 \cdot MgCO_3$. With these new minerals many others were found, such as the sodium borosilicate searlesite, the hydrous sodium calcium carbonates gaylussite and pirssonite, analcite, and the sodium magnesium chloride carbonate, northupite (FIGURE 2). By far the most important discovery of Fahey, however, was that the core contained tremendous thicknesses of trona, $Na_3H(CO_3)_2 \cdot 2H_2O$, in beds as much as 4 m. thick at a depth of less than 600m. The trona, now mined, is a major source of soda ash used in making glass and in hundreds of other industrial products. The beds extend over hundreds of square kilometers and aggregate billions of tons.

With World War II, Bradley and Fahey turned to urgent wartime duties, and it was not until many years later that they were able to resume their Green River researches. However, in 1952 an oil company geologist submitted a piece of oil shale from the Green River formation from Utah; the shale contained a peculiar unidentified mineral. After much study, the strange crystals were found to be leucosphenite, $CaBaNa_3BTi_3Si_9O_{30}$.

*This paper, illustrated with slides, was presented at a meeting of the Section on April 3, 1961.

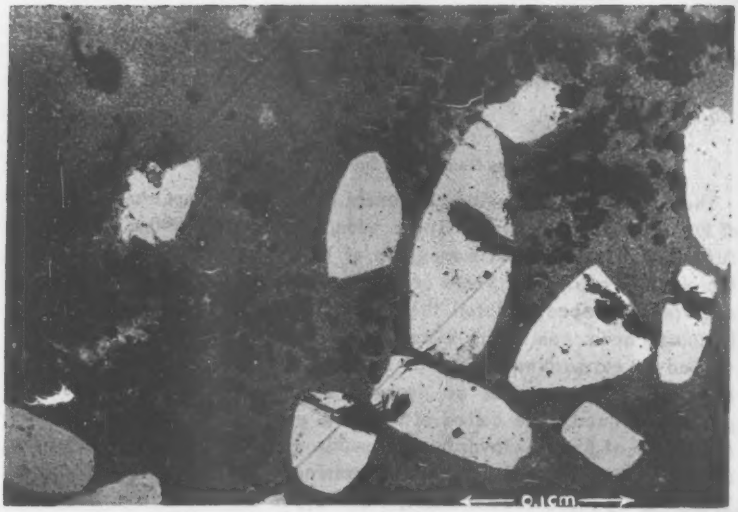


FIGURE 1. Acmite ($NaFeSi_2O_6$) with shortite $Na_2Ca_2(CO_3)_3$ in dolomitic marlstone. Wyoming. Thin section, ordinary light.

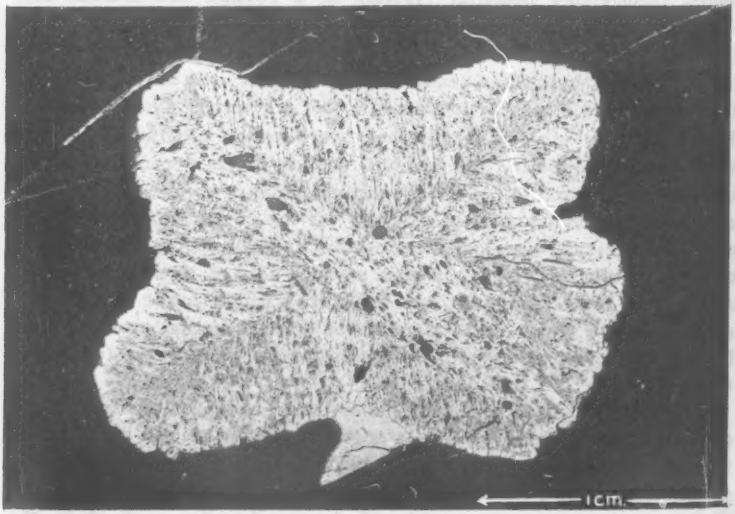


FIGURE 2. Acmite ($NaFeSi_2O_6$) gray oriented inclusions in a crystal of northupite $Na_2CO_3 \cdot MgCO_3 \cdot NaCl$; in dolomitic marlstone. Wyoming. Thin section, ordinary light.

At first it was impossible to believe that this mineral, known previously only from a pegmatite in southwestern Greenland, could have any genetic relationship to the oil shales of the Green River formation that are completely devoid of any igneous or metamorphic rocks. Nevertheless it was established that this leucosphenite was a true authigenic sedimentary mineral, formed in the bottom muds under absolutely nonmagmatic conditions. Immediately following, a whole suite of extraordinary minerals was discovered: a strange feldspar without aluminum, $NaBSi_3O_8$, structurally a boron albite; then a pyroxene, acmite, $NaFeSi_2O_6$; and sodic amphiboles, related to magnesioriebeckite (FIGURE 3 and 4), both found for the first time as authigenic sedimentary minerals. All these were associated with abundant shortite and nahcolite, indicating genetic relationship between this strange mineralogy in Utah and that revealed by Fahey in Wyoming.

This discovery opened up a new chapter in Green River mineralogy and petrology and, indeed, in sedimentary petrology itself. Not only was it evident that the Green River formation contained one of the world's most notable mineral assemblages but, even more interesting, that minerals hitherto known as crystallizing only from alkaline or pegmatitic magmas, here came into existence under conditions of lacustrine sedimentation, at temperatures far below the boiling point of water and pressures equally remote from anything approaching magmatic.

The authigenic mineralogy of the Green River formation is remarkably

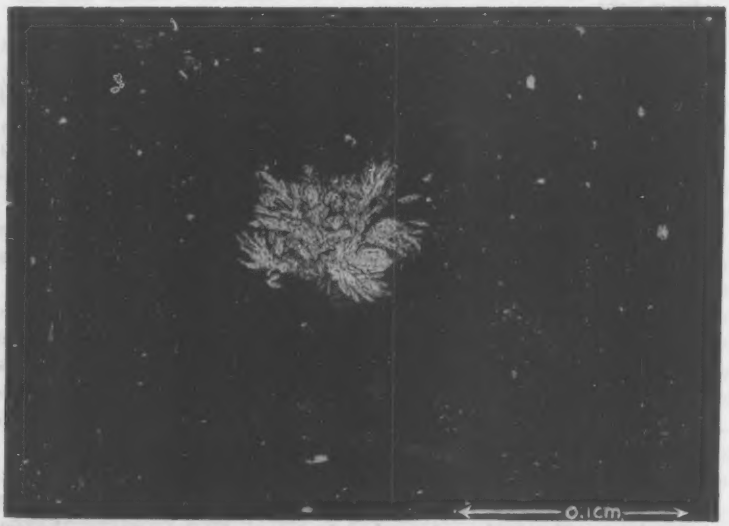


FIGURE 3. Magnesioriebeckite amphibole $Na_2(Mg,Fe)_3(Fe,Al)_2Si_8O_{22}(OH)_2$ in oil shale. This is the only known authigenic sedimentary amphibole. Utah. Thin section, ordinary Light.

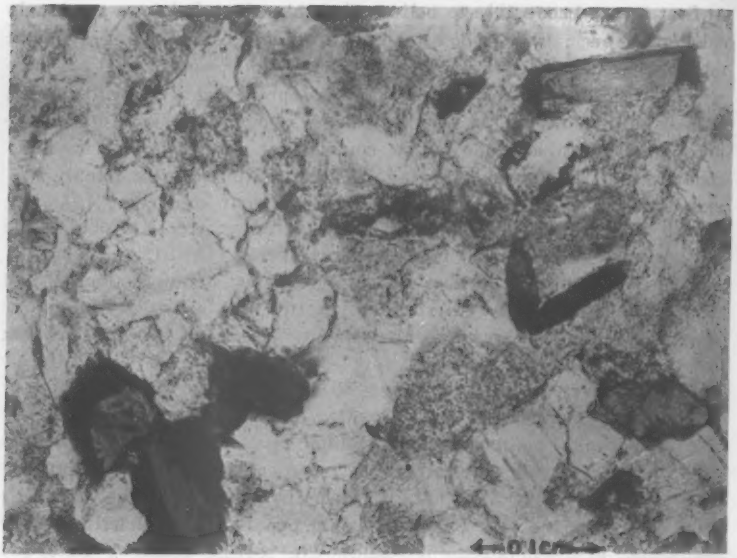


FIGURE 4. Riebeckitic amphibole. Crystal tuff with authigenic dark blue-black secondary amphibole overgrowing detrital hornblende. Utah. Thin section, ordinary light.

varied, about 50 species being known. More than one half of the known carbonate minerals of the world are present; there are also silicates, phosphates, chlorides, fluorides, oxides, sulfides, and many kinds of hydrocarbons. The silicates include complex titanium, boron, zirconium, and niobium silicates, such as labuntsovite (FIGURE 5); the carbonates include a rare-earth carbonate, complex phosphate- and chloride-carbonates, besides alkali (sodium) alkali-earth carbonates.

Of these minerals, at least eight are known only from the Green River formation, and seven others occur elsewhere in the world only in igneous rocks, pegmatites, or hydrothermal environments.

Papers by Milton and Fahey (1960*a*) and Milton *et al.* (1960), respectively, discuss the carbonate and the silicate mineralogy of the Green River formation; a second paper by Milton and Fahey (1960*b*) reviews the history of mineralogical research in the Green River. A general review, with emphasis on equilibrium studies, is given in Milton and Eugster (1959).

Many of these minerals are of special interest scientifically. Nahcolite, trona, and the newly discovered mineral $Na_2CO_3 \cdot 3NaHCO_3$ are phases in a physico-chemical system of primeeconomic importance. The large deposits of trona in the Green River formation are rapidly supplementing the Solvay process as a source of soda ash in North America. Eitelite,

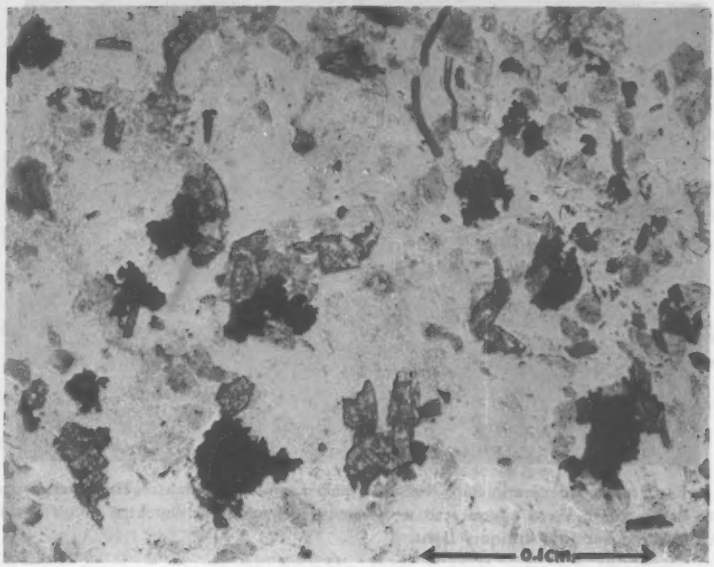


FIGURE 5. Labuntsovite (K, Ba, Na, Ca, Mn) (Ti, Nb) (Si, Al)$_2$ (O, OH)$_7$H$_2$O. The gray mineral with high relief is authigenic labuntsovite formed during diagenesis of a crystal tuff. Other minerals (detrital) are quartz, feldspar, mica; and pyrite (black). Labuntsovite also forms as euhedral crystals enclosed in trona, and also between layers of oil shale. Wyoming. Thin section, ordinary light.

$Na_2Mg(CO_3)_2$ is the second (fairchildite, $K_2Ca(CO_3)_2$, was the first) of a homologous group of alkali-alkali earth carbonates to be found in nature. These carbonates were synthesized in 1929 by Eitel and Skaliks. Reedmergnerite, $NaBSi_3O_8$, (FIGURE 6) a boron albite recently analyzed structurally by Clark and Appleman (1960) throws new light on fundamental problems of order and disorder in feldspar structure, which in turn will have direct bearing on many phases of igneous and metamorphic petrogenic theory. From another viewpoint reedmergnerite is significant as a phase in the system Na_2O-B_2O_3-SiO_2, basic in the study of borosilicate glass technology. Also, starting with the synthesis of reedmergnerite, Eugster and McIver (1959) have synthesized, by hydrothermal means, boron nepheline, boron kalsilite, boron mica, and other new substances, which may open new fields in ceramic technology. Northupite, $Na_2CO_3 \cdot MgCO_3 \cdot NaCl$ appears to have fixed in its structure a considerable part of the sodium chloride of the brines from the Green River formation; conceivably a process of desalination may be discovered in which northupite or related compounds play a part. Pyrite, one of the most widespread and abundant of minerals in the Green River formation, appears in Wyoming in extraordinary crystal forms found no-

FIGURE 6. Reedmergnerite $NaBSi_3O_8$ and magnesioriebeckite. Reedmergnerite is boron-albite, here associated with bands of magnesioriebeckite in oil shale. Utah. Thin section, ordinary light.

where else. Recently discovered apatite beds in the Green River formation extend for hundreds of kilometers, and carry uranium replacing calcium; this is true, as shown by Altschuler *et al.* (1958), of phosphates in Florida and elsewhere. A recent structure study by Christ (1959), of the silicoborate garrelsite (FIGURE 7) has clarified the re-

FIGURE 7. Garrelsite (BaCaMg) $B_2SiO_5(OH)_2$ in fissure in oil shale, showing characteristic striations. Utah.

markable stoichometric relations to datolite and bakerite in terms of tetrahedral boron-oxygen and silicon-oxygen linkages. Norsethite, a dolomite with barium instead of calcium, has been studied by Mrose and others (1961) and gives new understanding of calcite-dolomite and alkali-earth carbonate relationships. Neighborite, Na_2MgF_3, has been shown by Chao and others (1961) to be structurally related to perovskite, $CaTiO_3$; the study of this mineral, in particular its spinel-type twinning, may have significant bearing on electronic research in ferroelectric and piezoelectric substances such as $BaTiO_3$.

References

ALTSCHULER, Z. S., R. S. CLARKE & E. J. YOUNG. 1958. Geochemistry of uranium in apatite and phosphorite. U.S. Geol. Survey Prof. Paper 314-D: 45-90.

BRADLEY, W. H. 1931, Origin and microfossils of the Green River formation of Colorado and Utah. U.S. Geol. Survey Prof. Paper, 168:1-58.

CHAO, E. C. T., H. T. EVANS, Jr., B. J. SKINNER & C. MILTON. 1961. Neighborite, $NaMgF_3$, a new mineral from the Green River formation, Utah: Am. Mineralogist. 46: 379-393.

CHRIST, C. L. 1959. Garrelsite and the datolite structure group: Am. Mineralogist, 44:176,177.

CLARK, J. R. & D. E. APPLEMAN. 1960. Crystal structure refinement of reedmergnerite the boron analog of albite. Science. 132(1442):1837-1838.

EITEL, W. & W. SKALIKS. 1929. Über einige Doppelkarbonate der Alkalien und Erdalkalien: Z. anorg. u. allgem. Chem.:182, 263.

ERTL, T. 1947. Sodium bicarbonate (nahcolite) from Colorado oil shale. Am. Mineralogist, 32:117-120.

EUGSTER, H. P. & N. C. MCIVER. 1959. Boron analogues of alkali feldspars and related silicates (abs.) Geol. Soc. America Bull. 70:1598.

MILTON, C. & H. P. EUGSTER. 1959. Mineral assemblages of the Green River formation. *In* Researches in Geochemistry. P. H. Abelson, Ed. 118-150. New York, N.Y.

MILTON, C. & J. J. FAHEY. 1960a. Carbonate mineralogy of the Green River formation. Am. J. Sci. Bradley Volume. 258-A:242-246.*

MILTON, C. & J. J. FAHEY. 1960b. Green River mineralogy—a historical account: in Wyoming Geol. Assoc. Guidebook, 15th Ann. Field Conf., 1960, p. 159-162.

MILTON, C., J. J. FAHEY, M. E. MROSE &E. C. T. CHAO. 1960. Silicate mineralogy of the Green River formation. Intern. Geol. Congr. 21st, Copenhagen, 1960, Proc. Pt. 21:171-184.

MROSE, M. E., E. C. T. CHAO, J. J. FAHEY & C. MILTON. 1961. Norsethite, BaMg$(CO_3)_2$, a new mineral from the Green River formation, Wyoming. Am. Mineralogist. 1961. 46: 420-429.

*(This Volume contains a brief biography of Wilmot Hyde Bradley, geologist, geomorphologist, paleolimnologist, paleontologist, and administrator of the U.S. Geological Survey. His twelve papers are the foundation of Green River geology. The Volume—a "Festschrift"—includes 38 papers on all fields of geology by leading American geologists who have worked with Bradley.)

SECTION OF CHEMICAL SCIENCES

TETRAHYDRO–1,3–BENZODIAZEPINE: A NEW HETEROCYCLIC SYSTEM*

George deStevens and Marylou Dughi

Chemical Research Division, CIBA Pharmaceutical Products Inc., Summit, N.J.

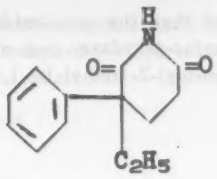
The initial concept leading to this work on tetrahydro–1,3–benzodiazepine has its genesis in two independent and unrelated developments. Several years ago Tagmann and Hoffmann[1] of our CIBA Basle Laboratories prepared 2-ethyl-2-phenylglutarimide (I) which was subsequently shown to be clinically effective as a nonaddicting hypnotic and sedative. Many chemical modifications were made of this glutarimide in an effort to determine whether substances with different biological effects could be obtained. One such change involved nitration. This led to a mixture of *o*-nitro and *p*-nitrophenyl derivatives. The crude nitration products mixture was in turn catalytically reduced to the *o*-amino and *p*-amino compounds that could be nicely separated by fractional crystallization. The 2-(*p*-aminophenyl)-2-ethyl-glutarimide was found to be a good anticonvulsant in humans but the corresponding *o*-aminophenyl derivative (II) was devoid of such biological effects. It thus became of interest to find a use for compound II since a considerable amount of it was isolated at the production level. Although II was subjected to several chemical transformations, its hydrolysis with acid was particularly intriguing since it gave rise to 3-(2-carbamylethyl)-3-ethyloxindole (III). Such a change is explained readily by scission of the glutarimide moeity followed by ring closure of the resulting intermediate to the stable oxindole structure. Thus a consideration of the reactivity of such an intermediate became of interest.

Concomitant with these findings, Ried[2] and his co-workers expanded the studies of Thiele[3] and Steimmig and reported on the preparation of a wide variety of 1,5-benzodiazepines. Their work revealed that *o*-phenylenediamine (IV) readily condensed with β-ketoesters to form 1,5-benzodiazepine derivatives (V). In addition, the biological importance of 1,4-benzodiazepines was emphasized by a report by Archer[4] *et al.* on the anticonvulsant action of 1-ethyl-4(3-tropanyl) tetrahydro-1*H*-1,4-benzodiazepine (VI), and by the clinical usefulness of methaminodiazepoxide[5] (VII) as a tranquilizer.

Finally, another member of this group, 1-*H*-1,3-benzodiazepine has recently been described *only* in derivative form by Plieninger[6] and

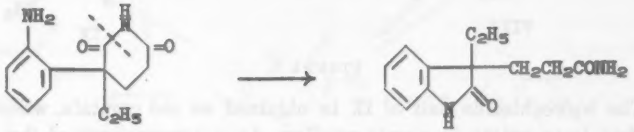
*This paper, illustrated with slides, was presented at a meeting of the Section on April 4, 1961.

The Division of Engineering held a meeting on April 3, 1961, at which Franz Ollendorf of the Technion-Israel Institute of Technology, Haifa, Israel, presented a paper entitled "Electrostatic Fields in Metals." This article will not be published by the Academy.



I

FIGURE 1.



II III

FIGURE 2.

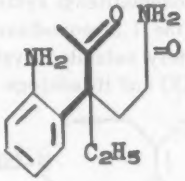
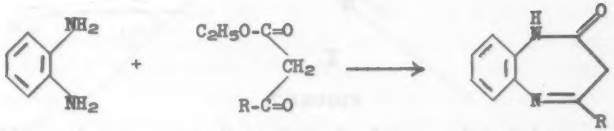
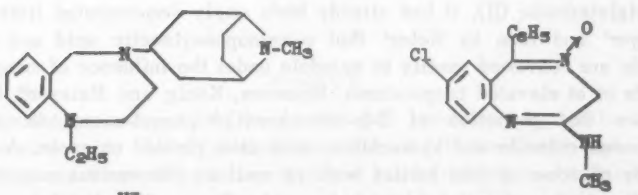


FIGURE 3.



IV V

FIGURE 4.



VI VII

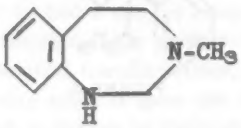
FIGURE 5.

Nogradi, who have found that the auto-oxidation of the lactone of β-(*o*-acetamidophenyl)-α-amino-γ-hydroxy crotonic acid (VIII) gives rise to the lactone of 5-hydroxymethyl-2-methyl-1*H*-1,3-benzodiazepine-4-carboxylic acid (IX).

VIII IX

FIGURE 6.

The hydrochloride salt of IX is obtained as red crystals, whereas the free base exists as purple needles. As a consequence of the unsaturation of the 3,4-bond in the butyrolactone portion of IX, the ring closure step can only form a "pseudoaromatic" compound whose properties resemble the benzocycloheptatrienyl system. Our interest in seven-membered heterocycles of the 1,3-benzodiazepine class was confined to the study of the completely saturated system, 1,2,4,5-tetrahydro-3-methyl-1,3-benzodiazepine (X) and its analogs.



X

FIGURE 7.

It appeared that the most facile path to these compounds would be through the amides of *o*-aminophenylacetic acid. However, in addition to the close similarity of this substance to the intermediate postulated to be responsible for the formation of III from 2(*o*-aminophenyl)-2-ethylglutarimide (II), it had already been amply demonstrated first by Baeyer[7] and then by Neber[8] that *o*-aminophenylacetic acid and its amide are converted readily to oxindole under the influence of mineral acids or at elevated temperatures. Moreover, König and Reissert[9] had shown that reduction of 2-(*o*-nitrophenyl)-*N*-phenyl-acetamide with stannous chloride and hydrochloric acid also yielded oxindole. A restudy of some of this earlier work as well as the various reactions leading to the seven-membered heterocycle, X, as outlined in Scheme I, has now been carried out in our laboratory and comprises the subject matter of this report. According to a modification of the Baumgarten[10] procedure, 2-(*o*-aminophenyl)-*N*-methylacetamide (XIV) was prepared

and treated with one molecular equivalent of formaldehyde and heated at 60° C. in 90 percent aqueous ethyl alcohol containing catalytic amounts of mineral acid or alkali.

SCHEME I

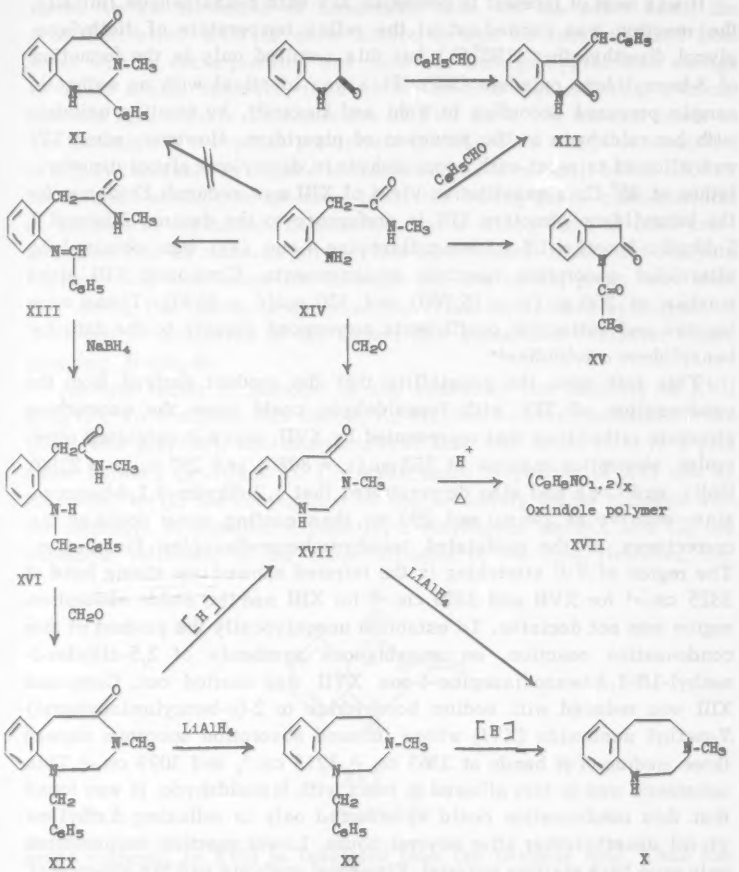


FIGURE 8.

Similar procedures had been employed previously by us for the preparation of 3,4-dihydrobenzothiadiazine-1,1-dioxides[11] and by Feldman and Wagner[12] in the synthesis of 1,2,3,4-tetrahydro-4-quinazolinones. In this instance, however, the acid-catalyzed reaction gave rise only to oxindole, whereas the base catalyzed reaction yielded predominantly oxindole plus a small amount (less than 3 percent) of a crystalline compound, m.p. 149° to 150°, whose elemental analysis

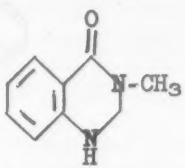
corresponds to XVII. However, when this condensation reaction was carried out in neutral solvents, such as absolute ethyl alcohol or diethylene glycol dimethylether, in the absence of alkali and at temperatures of 75° to 95° C., 75 to 80 percent yields of XVII were obtained.

It was next of interest to condense XIV with benzaldehyde. Initially, the reaction was carried out at the reflux temperature of diethylene glycol dimethylether (190° C.), but this resulted only in the formation of 3-benzylidene oxindole (XII). This was identical with an authentic sample prepared according to Wahl and Bagard[13], by treating oxindole with benzaldehyde in the presence of piperidine. However, when XIV was allowed to react with benzaldehyde in diethylene glycol dimethyllether at 95° C. a quantitative yield of XIII was secured. Evidence for the benzylidene structure XIII in preference to the desired 2-benzyl-2,5-dihydro-3-methyl-1*H*-1,3-benzodiazepine-4-one (XI) was obtained by ultraviolet absorption spectrum measurements. Compound XIII gives maxima at 260 mμ (ϵ = 15,760) and 320 mμ (ϵ = 6540). These wave lengths and extinction coefficients correspond closely to the data for benzylidene *o*-toluidine[14].

This left open the possibility that the product derived from the condensation of XIV with formaldehyde could have the azomethine structure rather than that represented by XVII, since it exhibited ultraviolet absorption maxima at 252 mμ (ϵ = 8080) and 297 mμ (ϵ = 2280). Holly and Cope had also demonstrated that 1,2-dihydro-3,1,4-benzoxazine absorbs at 246 mμ and 290 mμ, thus casting some doubt on the correctness of the postulated tetrahydrobenzodiazepine formulation. The region of *N-H* stretching in the infrared showed one strong hand at 3325 cm.$^{-1}$ for XVII and 3300 cm.$^{-1}$ for XIII and the amide absorption region was not decisive. To establish unequivocally the product of this condensation reaction, an unambiguous synthesis of 2,5-dihydro-3-methyl-1*H*-1,3-benzodiazepine-4-one XVII was carried out. Compound XIII was reduced with sodium borohydride to 2-(*o*-benzylaminophenyl)-*N*-methyl acetamide (XVI) whose infrared absorption spectrum showed three medium-*N-H* bands at 3363 cm.$^{-1}$, 3213 cm.$^{-1}$, and 3099 cm.$^{-1}$. This substance was in turn allowed to react with formaldehyde. It was found that this condensation could be effected only in refluxing diethylene glycol dimethylether after several hours. Lower reaction temperatures only gave back starting material. Elemental analysis and the absence of absorption bands in the -*N-H* region of the infrared served to confirm structure XIX. Hydrogenolysis of the benzyl group in XIX yielded the dihydro-1,3-benzodiazepine-4-one (XVII), which was identical in all respects with the substance obtained directly from condensation of XIV with formaldehyde. The preparation of 1,2,4,5-tetrahydro-3-methyl 1,3-benzodiazepine (X) in turn was accomplished through reduction of XVII with lithium aluminum hydride. By a similar sequence XIV was converted to X via XX.

It was found that 1,2,4,5-tetrahydro-1,3-benzodiazepine (X) was a highly unstable substance. It could only be isolated and identified as its maleic acid salt. As the free base, it exists as an oil that decomposes on standing. All attempts to prepare a mineral acid salt of X resulted in the formation of intractable tars. On the other hand, the 4-ketoderivative XVII is quite stable. It can be recrystallized from water without decomposition and does not undergo appreciable change in dilute alkali. However, it is worthy of note that refluxing a dilute aqueous hydrochloric acid solution of XVII for a few minutes leads to the formation of a copious precipitate (XVIII). This amorphous material is highly insoluble in organic solvents and does not melt below 330° C. Its infrared absorption spectrum lacks the strong detail characteristic of monomeric crystalline substances, but a strong band at 1690 cm.$^{-1}$ indicates that an oxindole polymer has been formed. Elemental analysis supports this view since one nitrogen and one methyl group have been lost during the course of the reaction. This facile acid hydrolysis of XVII can be attributed to the essentially acetal-like character of the grouping $\dot{N}\text{-}CH_2\text{-}\dot{N}$-.

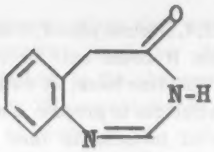
Another factor of interest is the unusually low basicity of XVII ($pK_a < 2$). To elucidate this matter, 1,2-dihydro-3-methylquinazolin-4-one (XXI) was prepared, and this compound also was found to have a pK_a value below 2 (FIGURE 9). The weak basic properties of XXI can be attributed to (1) the conjugation of the secondary amine nitrogen with the carbonyl in position 4 (that is, a vinylogous amide), and (2) the inductive influence of the amide nitrogen in the ring. However, the



XXI

FIGURE 9.

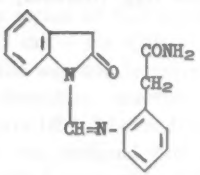
amide carbonyl in XVII is insulated from the benzene ring. Thus the inductive effect seems to be responsible for decreasing the basic properties of this heterocycle. This is supported by the results of Albert[15] and his co-workers, who showed that the introduction of a second nitrogen in a heterocyclic ring can reduce the basicity by as much as 3 pK_a units. In addition, a model of XVII reveals that the heterocyclic seven-membered ring exhibits internal strain effects resulting in a certain amount of bond oppositions[16]. This type of strain may also affect the basicity of the compound. Finally, an attempt was made to prepare 3,5-dihydro-1,3-benzodiazepine-4-one (XXII).



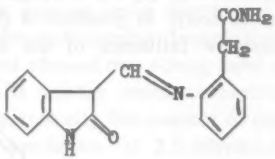
XXII

FIGURE 10.

Treatment of *o*-aminophenylacetamide with excess formic acid or formamide at their reflux temperatures only gave rise to oxindole. Similarly, XIV (see Scheme 1) was converted to *N*-acetyl oxindole (XV) in refluxing acetic anhydride. However, when *o*-aminophenyl acetamide was allowed to react with ethyl orthoformate under controlled conditions[17], a yellow crystalline substance, m.p. 227-228 was isolated. Its elemental analysis and molecular weight (307) by the Rast procedure corresponded to an empirical formula of $C_{17}H_{14}N_3O_2$. The infrared absorption spectrum contained bands in the *N-H* region at 3375 cm.$^{-1}$ and 3160 cm.$^{-1}$. A strong absorption band at 1690 cm.$^{-1}$ is attributed to the oxindole carbonyl while the 1655 cm.$^{-1}$ and 1625 cm.$^{-1}$ bands are associated with amide carbonyl and C = N groups, respectively. These data suggest either structure XXIII or XXIV.



XXIII



XXIV

FIGURE 11.

The structure of the dimer was determined unequivocally by synthesis. Condensation of *o*-aminophenylacetamide with 3-hydroxymethylene oxindole gave a product that was identical with XXIV.

References

1. TAGMANN, E., E. SURY & K. HOFFMANN. 1952. Helv. Chim. Acta. 35: 1235.
2. RIED, W. & A. DRAISBACH. 1959. Chem. Ber. 92: 2902.
3. THIELE, J. & G. STEIMMIG. 1907. Chem. Ber. 40: 955.
4. ARCHER, S., J. R. LEWIS, M. J. UNSER, S. O. HOPPE & H. LAPE. 1957. J. Am. Chem. Soc. 79: 5783.
5. STERNBACH, J. H. U.S. Pat. 2,893,992. July 7, 1959.

6. PLIENINGER, H. & I. NOGRADI. 1955. Chem. Ber. 88: 1965.
7. BAEYER, A. V. 1878. Chem. Ber. 11: 582.
8. NEBER, P.W. 1922. Chem. Ber. 55: 826.
9. KÖNIG, A. & A. REISSERT. 1889. Chem. Ber. 32: 782.
10. BAUMGARTEN, H.E., P.J. CREGER & R.J. ZEY. 1960. J. Am. Chem. Soc. 82: 3977.
11. WERNER, J.H., A. HALAMANDARIS, S. RICCA, JR., L. DORFMAN & G. DESTEVENS. 1960. J. Am. Chem. Soc. 82: 1161.
12. FELDMAN, J.R. & E.C. WAGNER. 1942. J. Org. Chem. 7: 31.
13. WAHL, A. & P. BAGARD. 1909. Compt. rend. 148: 716.
14. HOLLY, J.W. & A.C. COPE. 1944. J. Am. Chem. Soc. 66: 1875.
15. ALBERT, A., R.J. GOLDACRE & J. PHILLIPS. 1948. J. Chem. Soc. 2240.
16. BROWN, H.C., D.H. MCDANIEL & O. HAEFLIGER. 1955. Determination of Organic Structures by Physical Methods: 614. Academic Press, New York, N.Y.
17. TEOTINO, U.M. & G. CIGNARELLA. 1959. J. Am. Chem. Soc. 81: 4935.

SECTION OF BIOLOGICAL AND MEDICAL SCIENCES AND DIVISION OF MATHEMATICS

A NONLINEAR MODEL FOR A COMPUTER-ASSISTED MEDICAL DIAGNOSTIC PROCEDURE*

T. T. Tanimoto

Applied Science Division, Melpar, Inc., Watertown, Mass.

The primary objective for a computer-assisted medical diagnostic procedure is to determine exactly what symptomatic attributes characterize a set of known or unknown diseases and what the most discriminating factors are among the individuals of a given disease class when a large number of patients is considered. Obviously such a procedure is totally unnecessary when one considers patients with a complete set of symptoms that even a neophyte doctor can detect without difficulty. However, when considering a large population of patients whose general symptomatic profiles vary considerably, and whose definite disease classes are unknown, the use of a modern electronic computer is of great advantage because of its power to compare many things at the same time and its ability to make over-all decisions. The human mind can consider only a limited amount of information at one time: for example, three or four cases with their corresponding symptoms. The computer thus becomes a tool to aid the physician and in no way to replace him. The amount of information produced by the computer obviously cannot exceed the information input in the computer; however, it can point out explicitly obvious (but not *a priori* so) relations that exist in the data that a human finds obvious only after knowing what to seek. It also points out those elements that are, on the whole, most unlikely.

Let $\{p_i\}$, $i = 1,2,\ldots,n$ be a finite set of patients under consideration and $\{s_k\}$, $k = 1,2,\ldots,m$ be a finite set of symptoms that is of concern with respect to these patients (these are completely at the discretion of the medical expert in the field concerned, as are the choices of patients). Let (r_{ik}) be a large rectangular array or matrix such that $r_{ik} = 1$ if the patient p_i is attributed with the symptom s_k and $r_{ik} = 0$ if not; then it is possible to define measures of similarity of a pair of patients or a pair of symptoms by considering pairs of columns (column vectors) of the rectangular array, or matrix. (r_{ik}) or pairs of rows (row vectors) of the matrix. A very simple measure of similarity that we shall use is the ratio of the number of common symptoms to the number of symptoms positively involved: that is, the ratio of similarity σ_{ij} between patients p_i and p_j is given by

*This paper was the first of three papers presented at a joint meeting of the Division of Mathematics and the Section of Biological and Medical Sciences on April 5, 1961.

$$\sigma_{ij} = \frac{(\Sigma_k \min(r_{ik}, r_{jk})}{\Sigma_k \max(r_{ik}, r_{jk})}$$

where min (r_{ik}, r_{jk}) stands for the element that is the smaller of the numbers r_{ik} and r_{jk}, and max (r_{ik}, r_{jk}) stands for the larger of the two. Obviously, when r_{ik} are in general real numbers, then the above expression is a generalization of the ratio of counts of the "intersection" and "union" of Boolean vectors. The distance d_{ij} between the patients p_i and p_j is defined by

$$d_{ij} = -\log_2 \sigma_{ij}$$

so that if two patients are symptomatically close (that is, σ_{ij} is nearly one) then the distance between them is small, so that they are close in a geometrical sense as well as in a qualitative sense. If $\sigma_{ij} = 0$, then we shall say that patient p_i is not connected to patient p_j. Thus d_{ij} defines a metric graph with patients as nodes. To each node p_i we now associate an over-all number H_i defined by

$$H_i = \Sigma_j' d_{ij} = - \Sigma_j' \log \sigma_{ij}$$

where the prime on the summation symbol indicates that the sum is taken over only in the finite terms. The index i_o determined by

$$H_{i_o} = \min_i H_i = \min_i \Sigma_j' d_{ij} = -\max \Sigma_j' \log_2 \sigma_{ij}$$

is said to designate the most typical patient p_{i_o}. This patient, p_{i_o}, is that node which is nearest to all the other nodes or that which is nearest the centroid of the system of points. Since

$$H_{i_o} = \min_i \Sigma_j' \log_2 \sigma_{ij} = -\max \Sigma_j' \log_2 \sigma_{ij} = -\max_i \log_2 \Pi_j \sigma_{ij},$$

i_o can be interpreted to be determined by a maximum likelihood criterion, since the σ_{ij}'s are ratios of frequency counts that are the empirical probabilities of selecting a symptom that is common to both patients p_i and p_j out of all the symptoms concerning the two patients. The information in bits, $d_{ij} = -\log_2 \sigma_{ij}$, is conveyed by the event whose probability is σ_{ij}, so that the typical person p_{i_o} can be interpreted as being determined by that which yields the least information: that is, typical. The atypical patient is determined by the dual consideration and thus is the least likely and the most information-bearing patient. By applying the same type of analysis to the row vectors, the population or any subpopulation of patients can be characterized by the most typical symptoms. However, before going into the characterization of the population, we wish to know roughly some measure of inhomogeneity of

the population so that the subpopulation can be grouped if the data so dictates. A population will be said to be homogeneous or said to constitute a clump if the members are all interrelated to each other to the same degree; that is, if one member is just as similar to any other. In such a case the geometric entropy function has its maximal value; namely, $\log N$ where N is the total number of links involved in the graph in which all the pairwise distances are equal. Thus a reasonable measure of inhomogeneity is the deviation of the geometric entropy function of the working sample from the maximal case; that is, $E_{max} - E$. When normalized, this becomes $R = 1 - \frac{E}{E_{max}}$, which is the classical measure of redundancy of the system. Hence if R is nearly zero, the original population constitutes a clump. If however, the nearly common pairwise distances are large, then each element can be considered a clump. If, on the other hand, R is large, that is, near one, then the original population is quite inhomogeneous, so that the previously mentioned analysis can be performed to obtain the typical patient, p_{i_o}. An arbitrary open sphere is taken with p_{i_o} as the center, and this subpopulation is analyzed for its degree of inhomogeneity. If the proper threshold on the inhomogeneity measure is not met, peripheral elements are either introduced or eliminated, and the new inhomogeneity measure is recomputed and compared with the threshold. Iterations of this type determine a clump that can then be removed as a class and the whole procedure repeated on the remaining elements. Each subpopulation can then be characterized by the symptomatic profile produced by the same procedures applied to the symptoms.

If the original population is hand-picked such that they come from a well-determined disease class, then the analysis can be used for further discrimination within such a class.

BASIC MECHANISMS OF PUPILLARY MOVEMENTS*

Otto Lowenstein and Irene E. Loewenfeld

Department of Ophthalmology, Columbia University College of Physicians and Surgeons, and the Institute of Ophthalmology, Presbyterian Hospital, New York, N. Y.

Since the beginning of organized biological research the pupillary movements have attracted the attention of investigators in many fields of theoretical and applied physiology.

The iris, visible through the transparent cornea, shows little individual variations in size. The delicate responsiveness of the iris, the extensiveness of the nervous network controlling it, and the possibility of measuring its reactions accurately without touching the body, make the iris an ideal test object for the investigation of autonomic nervous mechanisms and, clinically, for the detection of lesions within the centers and pathways of pupillary control.

The iris is an extraordinarily mobile structure. In man, the pupillary diameter may vary from 1.5 to more than 9mm; in some other species the range of movement is even larger. These movements are brought about by a double set of smooth muscles, namely (1) the pupillary sphincter, innervated by parasympathetic (cholinergic) nerves and (2) the dilator muscle of the pupil, supplied by sympathetic (adrenergic) fibers. The iris is thus representative of all structures reciprocally innervated by the autonomic nervous system.

Pupillary reflexes are integrated movements. Under normal conditions both pupillary contraction and dilation conform to definite time-amplitude patterns that are similar in all mammals.† Graphic analysis of these reaction patterns – registered by infrared recording techniques under various experimental conditions – reveals the mechanisms responsible for the movements. An analysis of pupillary reflex dilation may serve as example.

When a sleepy cat is suddenly subjected to a strong sensory stimulus such as sound or pain, the pupil dilates with great rapidity. It becomes maximally enlarged and may remain large for minutes. In anesthetized animals, a strong hypothalamic stimulus will elicit a similar reaction (FIGURE 1, solid line). At least four mechanisms are known to contribute to these responses.

Sympathetic Innervation

Hypothalamic discharges, elicited reflexly or due to electrical stimu-

*This paper, illustrated by a motion picture, was presented at a joint meeting of the Section of Biological and Medical Sciences and the Division of Mathematics on April 5, 1961.

The work described in this paper was supported in part by the Harriman Fund, New York, N.Y., and by Research Grant B-253 from the National Institute of Neurological Diseases and Blindness, Public Health Service, Bethesda, Md.

† For more extended presentation see bibliography.

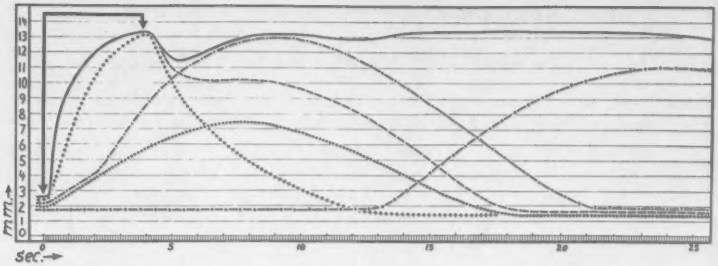


FIGURE 1. The mechanisms of pupillary dilation. Pupillary diameter is plotted as the ordinate (in mm.) against time as the abscissa (in 0.1-sec. U.). The double arrow marks the time of stimulation.

The solid line represents the complete response of the normal pupil to a strong stimulus of less than 5 sec. duration (cortical, diencephalic, or sensory stimuli in awake cats, hypothalamic stimulation in narcotized animals). The pupil dilates with great rapidity and reaches maximal size within 3 to 4 sec. After an initial contraction at the end of the stimulus, it dilates anew and may remain very large for minutes. The analysis of this movement reveals the following component mechanisms: (1) active innervation of the dilatator pupillae by sympathetic impulses, characterized by relatively fast dilation and recontraction *(line of crosses);* (2) inhibition of the oculomotor nucleus *(dotted line)* leads to slower, somewhat longer-lasting pupillary dilation. (3) an adrenergic substance different from adrenal epinephrine is carried to the eye by the blood *(dash-cross line);* (4) adrenal epinephrine and, possibly, adrenergic substances from other sources arrive at the eye about 9 to 15 sec. after the start of stimulation *(dash-dot line).*

In response to strong stimuli, the humoral factors intensify and prolong the pupillary dilation movement initiated by the synergistic combination of the two neural mechanisms. In contrast, stimulation by weak or moderate stimuli does not appear to evoke the production of humoral substances in sufficient quantity to affect the normal pupil, which is dilated by the neural mechanisms alone (shown by broken line). Reproduced from Figure 61 of Loewenfeld (1958) by permission of *Documenta Ophthalmologica.*

lation in the hypothalamus, travel via the brain stem to the cervicothoracic spinal cord; they activate sympathetic impulses that reach the eye by way of the cervical sympathetic nerve and the superior cervical ganglion. Sympathetic activity is the chief cause of rapid and extensive pupillary reflex dilation, as shown – among other proofs – by the following facts: (1) electrical stimulation of the cervical sympathetic nerve causes maximal pupillary dilation (FIGURE 1, line of crosses); (2) when the peripheral sympathetic path is interrupted, pupillary reflex dilation becomes slow and inextensive (FIGURE 1, dotted line); and (3) after intravenous injections of dibenamine and similar sympathicolytic drugs, pupillary reflex dilation, likewise, becomes inextensive and slow.

Inhibition of the Oculomotor Nucleus

After the sympathetic path to the eye has been interrupted, the pupil

continues to dilate in response to sensory or emotional stimuli, although the movement is much reduced in extent and speed (cf. previous paragraph and FIGURE 1, dotted line). This fact has given rise to much controversy in the literature:

(1) Many authors assumed that, after interruption of the cervical sympathetic path, residual sympathetic innervation of the iris took place over secondary pathways. Accessory sympathetic fibers were thought to reach the eye via the third, fourth, fifth, sixth, seventh, or twelfth cranial nerve, the upper cervical or the vertebral nerve, or from ganglion cells situated in the Gasserian ganglion, the ciliary ganglion, or the iris itself. However, none of the nerves thus considered as possible accessory sympathetic paths has ever been proved actually to conduct sympathetic impulses. In addition, all these assumptions can be disproved experimentally: *(a)* the remnant dilation to sensory or emotional stimuli that survives interruption of the cervical sympathetic path is *not* further reduced by intravenous injections of sympathicolytic drugs such as dibenamine, but *(b)* it is abolished when the pupillary sphincter is paralyzed by atropinelike substances, by interruption of the third nerve or by removal of the ciliary ganglion.

The movement is thus not adrenergic in nature but is due to a reduction of cholinergic impulses to the pupillary sphincter. This reduction of parasympathetic activity was shown to be due to inhibition of the oculomotor nucleus; elicited by the sensory stimulus, the inhibitory impulses converge upon the third nerve nucleus from cortex, thalamus, and hypothalamus and – in cats more than in primates – via direct afferent connections in the diffuse reticular formation.

(2) Two neural mechanisms, then, take part in the pupillary dilation elicited by sensory or emotional stimulation. Contraction of the sympathetically innervated dilatator pupillae coincides with relaxation of the sphincter muscle due to inhibition of its motor nucleus. The opinions held by various authors concerning the relative importance of these two neural mechanisms are widely divergent. These controversies arose mainly because of the varying results obtained from awake and from anesthetized animals.

In awake animals, maximal sympathetic responses are easily obtained by sensory or by emotional stimulation. However, when the animals are anesthetized, the active sympathetic component of pupillary reflex dilation is abolished, and the pupils are dilated by the mechanism of parasympathetic inhibition alone:

(a) In unilaterally sympathectomized animals, the pupils on the normal and on the operated side dilate equally during anesthesia (dotted line of FIGURE 1), while in the awake animal, the normal pupil reacts much faster and more extensively (solid line of FIGURE 1).

(b) When the third nerve is cut, the ciliary ganglion removed or atropine instilled into the eye, sensory stimuli fail to affect the parasympathecto-

mized pupil of the anesthetized animal while the normal pupil slowly dilates until it becomes as large as the parasympathectomized one (about four fifths of maximal). In the awake animal, both pupils dilate quickly to maximal size.

(c) When relaxation of the pupillary sphincter is prevented by instillation of a parasympathicomimetic drug such as physostigmine into the eye, sensory stimuli fail to affect the pupil of the narcotized animal, although electric stimulation of the cervical sympathetic nerve as well as sensory stimuli in the awake animal remain effective.

An analysis of the pertinent literature shows that the majority of authors who came to the conclusion that sensory or emotional stimuli fail to elicit sympathetic responses worked with deeply narcotized animals, while those who reported sympathetic effects worked without anesthesia or used light narcosis by volatile agents.

Reflex Integration

The interaction of agonist and antagonist in the production of integrated reflexes is demonstrated clearly by the dynamic structure of the pupillary movements.

When the peripheral sympathetic chain of anesthetized animals is stimulated by maximal currents, the pupillary dilation is surprisingly slow compared to the velocity of pupillary reflex dilation in awake animals. This low peak speed is maintained for a relatively long time, while the speed of the normal reflex dilation declines almost immediately after its high peak has been reached (FIGURE 2*a* and *a'*).

In this respect and, indeed, in all others, reflex dilation of the pupil was found to be the exact (upside-down) mirror image of pupillary reflex contraction elicited by light (cf. FIGURE 2*b* and *b'*). In contrast to the course of these natural reflexes, both pupillary dilation in response to electrical stimulation of the cervical sympathetic chain and pupillary contraction upon excitation of the ciliary ganglion showed relatively low, long-lasting, plateau-shaped peaks of speed. Such "plateaus" are never found in natural pupillary movements. When a physiological stimulus is weak enough to elicit a reaction of low velocity, this reaction is always inextensive and shortlasting. However, the artificially induced movements are even more extensive than the normal reflexes. What could be the cause of this strange phenomenon?

It appeared likely that the absence of the parasympathetic-inhibitory factor of normal reflex dilation was responsible for the relative slowness of the purely efferent sympathetic responses. Experiments were therefore done in which sensory (sciatic) stimulation, known to inhibit the oculomotor nucleus in narcotized animals (cf. previous paragraph) was added to the sympathetic stimuli. As expected, the reactions elicited by such combined sensory and sympathetic excitation were similar in all features to natural reflex dilation of the pupil.

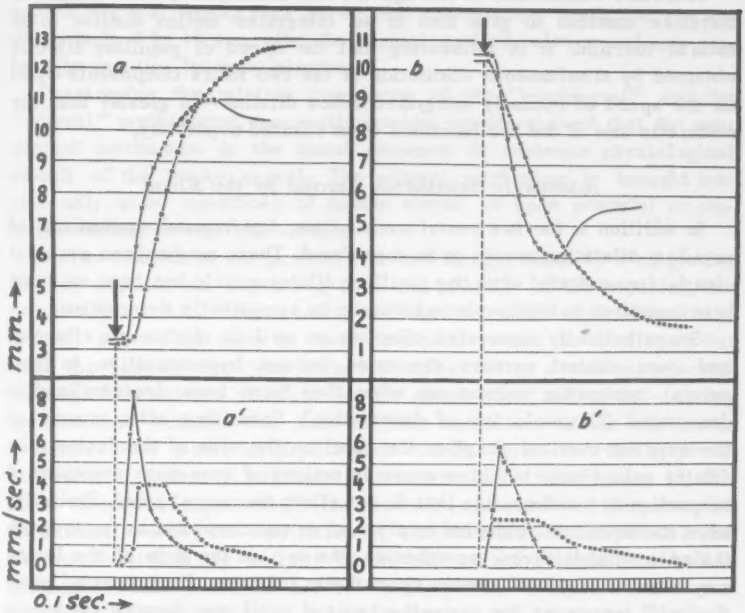


FIGURE 2. Pupillary motions elicited by electric stimulation of motor nerves, compared to natural, integrated reflex-movements. In the pupillograms (*a*, *b*), pupillary diameter is plotted as the ordinate (in mm.) against time as the abscissa (in 0.1-sec. U.) Each dot, respectively cross, indicates an individual measuring point (records taken at 10/sec. rate). The differential curves (a', b') show the increasing *(up)* and decreasing *(down)* speed at which the motions of a and b take place (in millimeters per second). The arrows indicate the beginning of stimulation.

The animals were anesthetized during the electrical stimulation experiments; during physiological stimulation they were awake.

(*a* and a') Electrical stimulation of the cervical sympathetic nerve caused maximal pupillary dilation (*line of dots*), but the movement was much slower than the dilation elicited reflexly in the awake animal (fright reaction, *line of crosses*). The differential curve of the natural motion showed fast acceleration to a high peak, followed by gradual decline of dilation speed. In contrast, the electrically induced dilation maintained a relatively low speed-"plateau" for more than one-half second. It should be emphasized that the sympathetic chain was stimulated with maximal intensity (Thyratron, 100 v at 50/sec.).

(*b* and b') Contraction of the pupil induced by electrical stimulation of the ciliary ganglion *(line of dots)*, compared to normal reflex contraction to light in the awake animal (*line of crosses*). The contraction movements were the (upside-down) mirror images of the dilation movements shown in *a* and a'. Reproduced from Figure 52 of Loewenfeld (1958) by permission of *Documenta Ophthalmologica*.

Artificial stimulation of the agonist and inhibition of the antagonist therefore combine to give rise to an integrated motion similar to the natural function. It is interesting that the speed of pupillary dilation obtained by simultaneous elicitation of the two reflex components – just as the speed of normally integrated reflex dilation – is greater than the arithmetic sum of the two functions when elicited separately.

Adrenergic Substances Carried by the Blood

In addition to the two neural mechanisms, two humoral mechanisms of pupillary dilatation remain to be considered. These mechanisms are most clearly demonstrated after the pupillary dilator muscle has been rendered hypersensitive to adrenergic substances by sympathetic denervation.

Sympathetically innervated effectors as well as cholinergic effectors and even central nervous structures become hypersensitive to their natural transmittor substances when they have been decentralized or denervated (Cannon's law of denervation). Some time after removal of the superior cervical ganglion the pupil on the side of the lesion thus dilates extensively to intravenous injections of very weak solutions of adrenaline or noradrenaline that do not affect the normal pupil. Similarly, when the animal is subjected to physical or emotional stress (or to hypothalamic stimuli during anesthesia), the eye on the side of the lesion may show all signs of intense sympathetic irritation. During such "paradoxical" responses the sympathectomized pupil may become maximally enlarged and it may remain larger than its normal fellow pupil for some time.

Since physical and emotional stress as well as hypothalamic stimulation are known to stimulate adrenal output, the "paradoxical" pupillary response is generally believed to be caused by adrenal epinephrine that has been released into the blood stream either reflexly or in answer to the hypothalamic stimulus. Pupillographic analysis of the onset, rate, and duration of the reactions shows, however, that two separate humoral mechanisms must exist:

(1) The acceleration of the dilation movement that is brought about by the arrival of humoral substances in the iris begins within 2 to 3 sec. after the start of stimulation, and the paradoxical reaction seldom requires more than 7 sec. to be fully developed. After moderate stimuli the responses often begin to decline within less than 10 sec. Adrenal epinephrine, as well as substances from all other organs discharging into veins, could not reach the eye in so short a time. Adrenergic substances are known to be liberated when the sympathetic nerves to the heart and the arteries are stimulated. These substances, reflexly poured out in response to sensory or emotional stimulation, are likely to enter the arterial circulation and to be the cause of the paradoxical pupillary response.

(2) In answer to strong or prolonged stimulation, adrenergic substances poured out into veins, such as adrenal epinephrine, reach the eye approximately 9 to 15 sec. after the beginning of stimulation and may prolong the reaction for many minutes.

Considering the relative importance of the "nonadrenal" and the "adrenal" mechanisms, our pupillographic records showed that the nonadrenal mechanism is the usual response to moderate physiological stimuli of the awake animal. The adrenal mechanism is brought into play only under conditions of severe stress, or upon powerful or prolonged central nervous stimulation.

Reflex dilation of the pupil is thus not brought about by a single but by four mechanisms. Depending upon the intensity of the stimulus, the sensitivity of the effector cells, and various other experimental conditions, one or the other of these mechanisms may be abolished, but when the normal, conscious animal is subjected to a sudden, powerful sensory or emotional stimulus – or the anesthetized animal to a strong hypothalamic stimulus – all four of them contribute to the movement.

Similar laws govern all pupillary movements. Thus the extent, speed, and dynamic pattern of pupillary reactions to light depend upon (1) the state of retinal adaptation, (2) the intensity, duration and frequency of the stimuli, and (3) the equilibrium of sympathetic, parasympathetic and supranuclear-inhibitory activity at the moment of stimulation. A discussion of these reactions and of other pupillary reflexes exceeds the scope of this summary.

References

CANNON, W. B. & A. ROSENBLUETH. 1949. The Supersensitivity of Denervated Structures; A Law of Denervation. MacMillan. New York, N. Y.

LOEWENFELD, I. E. 1958. Mechanisms of reflex dilatation of the pupil. Historical review and experimental analysis. Documenta Ophthalmologica. XII: 185-448.

LOWENSTEIN, O. 1955. Pupillary reflex shapes and topical clinical diagnosis. Neurology. 5: 631-643.

LOWENSTEIN, O. 1956. Pupillography. Methods and diagnostic system. A. M. A. Arch. Ophthalmol. 55: 565-571.

LOWENSTEIN, O. 1959. Electronic pupillography. Why, how and when? Eye, Ear, Nose and Throat Monthly. 38: 549-558.

LOWENSTEIN, O. & I. E. LOEWENFELD. 1950. Role of the sympathetic and the parasympathetic system in reflex dilation of the pupil. Arch. Neurol. Psychiat. 64: 313-340.

LOWENSTEIN, O. & I. E. LOEWENFELD. 1950. Mutual role of sympathetic and parasympathetic in shaping of the pupillary reflex to light. Arch. Neurol. Psychiat. 64: 341-377.

LOWENSTEIN, O. & I. E. LOEWENFELD. 1951. Types of autonomic innervation and fatigue. Arch. Neurol. Psychiat. 66: 580-599.

LOWENSTEIN, O. & I. E. LOEWENFELD. 1952. Disintegration of central autonomic regulation during fatigue and its reintegration by psychosensory con rolling mechanisms. I. Disintegration. II. Reintegration. J. Nervous Mental Diseases. 115 (1 and 2).

LOWENSTEIN, O. & I. E. LOEWENFELD. 1958. Electronic pupillography. A new instrument and some clinical application. Arch. Ophthalmol.:352-363.
LOWENSTEIN, O. & I. E. LOEWENFELD. The Pupil. *In* Physiol. of the Eye.

DIVISION OF PSYCHOLOGY

EVALUATION OF CANDIDATES FOR THE PROFESSIONS*

Wimburn L. Wallace

The Psychological Corporation, New York, N. Y.

Implicit in the consideration of the evaluation of candidates for the professions is the concept of prediction. When admissions committees of professional schools act favorably on the applications of some individuals for entrance and reject others, they do so on the basis of predicting some criterion. Typically, a major element of this criterion is successful negotiation of the requirements of the professional school curriculum; others may be estimated personal fitness for the professions, such as promise of ultimate contributions to the field and ethical practice.

In The Psychological Corporation we are deeply involved in testing programs designed to predict academic success in professional schools. We develop tests and conduct the entrance examinations for a number of professional fields. Since those with which we are associated are predominately in the health professions, for example, medicine, nursing, dental auxiliaries, and veterinary medicine, my remarks and illustrations will reflect this experience to some extent. We do not contend that such admission tests directly assess the potential of candidates for eminence or even for satisfactory practicing ability as members of the professions they seek to enter. Rather we concentrate on predicting likelihood of success in the academic work of the professional school. The logic is simple: if a student fails to complete the required professional training satisfactorily, he is not going to be any kind of a member of the profession: good, bad, or indifferent. Furthermore, if a student does not make the grade in the first year of training, he will not have the opportunity to progress nearer the goal; therefore first-year performance becomes the immediate criterion for selection techniques.

*This paper was the second of three papers presented at a meeting of the Division on April 17, 1961.

The Section of Biological and Medical Sciences and the Division of Mathematics held a joint meeting on April 5, 1961, at which Manfred Clynes, of Rockland State Hospital, Orangeburg, N.Y., presented a paper entitled "Biocybernetic Studies of Human Autonomic Functioning: Physiological Results of Control System Theory Application to Biological Problems." No paper has been received for publication.

The Section of Biological and Medical Sciences held a meeting on April 10, 1961, at which Thomas Goreau of the University College of West Indies, Mona, St. Andrew, Jamaica, British West Indies, presented a paper entitled "New Concepts of Coral Reef Physiology and Ecology." No manuscript has been received.

The Division of Instrumentation held a meeting on April 11, 1961, at which Moise H. Goldstein, Jr. of the Massachusetts Institute of Technology, Cambridge, Mass., presented a paper entitled "Computer Techniques in Neurophysiological Research." This paper will not be published by the Academy.

The Division of Psychology held a meeting on April 17, 1961, at which Jerome E. Doppelt of The Psychological Corporation, New York, N.Y., presented a paper entitled "The Testing and the Selection of Scientific Personnel." No manuscript has been received.

Incidentally, first-year achievement in any case is usually the best predictor of success in subsequent academic years.

Furthermore, these entrance examinations are intended only to predict probable success in the particular professional curriculum under consideration. They are not intended as tools for vocational guidance, that is, to reveal clues as to what occupation the individual might be best suited. For that matter, sophisticated educational and vocational counselors will rarely if ever indicate in any real or hypothetical case that the pattern of abilities, interests, personality traits, and background factors fit the person for one single narrow professional area. They are more likely to suggest families of occupations that are not contraindicated. More than 30 years ago, when testing for special or separate abilities was in its infancy, Clark Hull[1] expressed the hope that someday we might have precise measures of most human abilities and concomitantly know the weights for combining them into patterns indicative of success in each major occupation. He suggested that with this information and an appropriately programmed computer, the results from a battery of tests be submitted to the computer which, in turn, would emit scores or profiles indicating the probability of success in each of a wide variety of occupations. We now have adequate computers, and we have vastly improved tests of special abilities, but still Hull's dream has not come true. Why? Dael Wolfle[3] astutely summarized the reason in his Bingham Memorial Lecture last year: " ... relatively diverse patterns of ability are consistent with success in a single vocation. Any professional field includes opportunities for such a variety of persons – persons differing in abilities and differing in personality traits – that there is no simple or single pattern that is either essential or sufficient. Consider engineering, or medicine, or psychology, or any other field of work that demands intellectual ability. Each title covers a wide variety of tasks; each field includes opportunities for a wide variety of persons."

Hence, in designing selection tests or in the actions of admissions committees, no single set of uniform trait requirements can reasonably be established for selecting the successful professional practitioners of tomorrow. There is no such thing as "the physician of the future" when the phrase implies characterization of a narrow sort. There is both opportunity and need for the different kinds of individuals who become surgeons, psychiatrists, general practitioners, researchers, instructors, and members of all the other specialties of medicine. The same situation pertains equally in other professions.

With this state of affairs before us, then, what are the current and future proper functions of tests and of selection committees? Tests of general scholastic ability have the greatest validity for predicting success in the first year of professional education; therefore we are obliged to use this type of instrument. There is probably wisdom, how-

ever, in considering some specialized ability tests that would not yield maximum group validities across whole classes of professional school students but would identify some potentially valuable members of the professions: valuable not because of their wide general ability but because of some pertinent special abilities that would enable them to make either satisfactory or outstanding contributions to their fields. Chances of error are so plentiful in such gambles, however, that those responsible for selecting students to enter professional schools (hence to occupy some of the restricted number of places available in those colleges and to displace other candidates) rarely feel they are justified in dealing with such odds. Probably the more fruitful approach in testing in the future would be to continue with tried and true predictors of early success in basic professional training than to try to develop instruments that would predict selection and success in specialties within the profession, especially instruments intended for use sometime after admission to the basic professional program with the purpose of enhancing the chances of selecting appropriate specialization later.

As for the functions of admissions committees, McConnell [3] among others, has voiced a concern about what admissions committees for professional schools can use as the image against which to measure a candidate. He emphasizes the urgent need for greater precision in ultimate criteria that we all recognize as the major outstanding enigma in selection and prediction.

A recent survey of the practices in all the medical schools in the country indicated that the bases of selection typically given greatest weight were, in the intellectual area, undergraduate academic record, recommendations of premedical advisors, Medical College Admission Test results, recommendations from specific interviewers and, in the nonintellective area, the personal interview, written evaluations by premedical advisors, and extracurricular activities. In reviewing the undergraduate academic record, special attention is usually given to courses deemed especially crucial as preparation for professional school (science in the case of medical colleges). As Lowell Kelly has pointed out, however, the amount of science in the undergraduate record is sometimes misleading to unwary admissions committees; weak students often tend to take more courses in science to bolster their records, but they still may do poorly in medical school. When an admissions committee is impressed by the *amount* of extra science in the undergraduate record, the validity of their prediction may actually be depressed below what it would have been if its members had ignored the undergraduate record entirely.

Recommendations of preprofessional advisors and special interviewers whose standards are known to an admissions committee are considered important and revealing to most committees. There have been instances, however, when the preprofessional advisors have done

distinct disservice to a profession by striving to encourage and recommend only those candidates who they feel almost certain will make good records in professional school. By so doing, they pre-empt some of the functions that the admissions committees would prefer to retain themselves and probably discourage a number of reasonably promising candidates from entering the professions of their choice. Such negative counseling should be replaced by positive suggestions to the effect that those who aspire to a particular profession but do not fall in the top stratum in ability should seek to enter professional schools where the standards for admission may not be quite so rigorous as they are at the top-prestige colleges. I am reminded at this point of a cartoon that appeared in the *New Yorker* several years ago accompanied by the caption, "But Lois, he is only an average genius." There is room for many "average geniuses" in every profession, and there are many entirely respectable professional schools that would welcome some of these average geniuses in their classes.

Admissions committees use entrance examination results regularly both on an absolute basis (by this I do not mean with a rigid cutting score, but for the information and evidence they yield in and of themselves) and as a commoner across the variations of standards in the grading and recommending that inevitably arise from the wide range of undergraduate sources of candidates.

Among the nonintellective bases for selection, admissions committees give the greatest weight to the personal interview despite the warnings of the occasional cantankerous psychologist who points out the lack of published evidence for the validity of the interview in predicting success. It is still considered an important opportunity to verify and clarify information already gained through other means, to observe poise, frankness, and bearing, to estimate motivation and ethics, and to note any handicaps.

Of course a number of other factors, hard to describe and harder to admit, creep into the decisions of selection committees. For instance, there are probably some colleges of medicine that limit the number of women admitted in any given class on the basis that the likelihood of their remaining active in the profession is relatively low. Feminists may decry this practice, but the conscientious admissions committee faces a dilemma in being fair to all applicants on the one hand and filling their responsibility to award the limited facilities of medical education to those most likely to serve the profession and society on a regular and permanent basis; no reliable predictor exists that can tell those women who will stay in the profession and those who will not. Of course, schools of dental hygiene throughout the country are even more discriminatory; none of them will admit any males.

In quite another sense than we have been considering, selection for the professions starts at a very early stage. Considerable evidence

has been gathered by F.L. Strodtbeck, A. Roe, S. Stouffer, R. De Haan, R.J. Havighurst, and others, to show that cultural background, race, religion, sex, encouragement, and opportunity provided by parents, teachers, and others all have strong effects on career selection.

During high school years, self-selection is occurring in the process of the development of occupational goals, influenced by the popularity or prestige of various occupations and a matching of the stereotype of the many fields against self-estimates of abilities and interests. Sometimes high school faculty members are more or less influential in this vocational goal selection process. However, stereotypes of the various professions are often erroneous or incomplete in comparison with actual practice, and estimations of the ease or difficulty of completing professional preparation may readily be distorted. Here, I believe, is one place where the professions could do an invaluable service to themselves, to the coming generation, and to society. They could take a far more active role in supplying representatives to the high schools to provide interested pupils with as accurate and complete a picture as possible of the conditions of entering their fields, including admissions and the completion of academic preparation, and the activities involved in the practice. Interest and decisions based on accurate information about the professions have far greater probability of permanence than those evolving from more superficial impressions. This approach would also fulfill much of the recruiting need felt to be necessary, or at least desirable, to assure the ranks of the professions their share of able youth: a more fruitful approach than a type akin to commercial advertising. Emphasis on the needs of society rather than on the preferences of the individual will influence very few candidates indeed.

In concluding these random remarks on the far-reaching topic of evaluation of candidates for the professions, may I observe that many conscientious and qualified people devote great segments of time and energy to the task of awarding to those they deem best qualified the limited number of places in professional educational institutions. Without exception they assume their responsibilities gravely, and eagerly but judiciously apply all the pertinent information they can acquire and marshal in arriving at their decisions. Whimsey plays no role in their work.

Although knowledge and skill will always be vital criteria of professional practice, we are likely to become increasingly interested in the prediction of nonacademic and ethical values. The degree of idealism of the professional practitioner, his sensitivity in dealing with his patient as a person, his awareness of the importance of factors outside his field, and other such characteristics are qualities that are related to the value of the professional person's contribution. The task of predicting success in these areas is very difficult, but it is clearly a task that must be undertaken.

References

1. HULL, C.L. 1928. Aptitude Testing. World Book. Yonkers, N.Y.
2. MCCONNEL, T.R. 1957. Reflections on medical education and some of the problems of selection. *In.* H.H. Gee and J.T. Cowles. The appraisal of Applicants to Medical Schools. Assoc. Am. Med. Coll. :17. Evanston, Ill.
3. WOLFLE, D. 1960. Diversity of talent. Am. Psychologist. 15: 535-545.

SECTION OF PHYSICAL SCIENCES

EXCITON SPECTRA AND THEIR MAGNETO OPTICAL EFFECTS*

R.G. Wheeler and J.O. Dimmock

Sloane Physics Laboratory, Yale University, New Haven, Conn.

Insulator and semiconductor crystals are characterized at absolute zero by a completely filled valence band and an empty conduction band. Upon absorption in the crystal of a photon of energy greater than the energy difference between these bands an electron-hole pair is produced. The electron and hole produced in this way are free and may move independently of each other, giving rise to photoconductivity. However, since the electron and hole have an attractive Coulomb interaction, it is possible for stable bound states of the two particles to be formed. The photon energy required for such an excitation will be less than the gap energy by the amount corresponding to the binding energy of such a pair of particles. This electrically neutral excitation so formed is designated as an exciton. When one considers the weakly bound case, as first suggested by Mott[1] and Wannier[2], where the effective mass approximation is valid, a rather simple hydrogenic picture is apparent. This approximation is valid when the exciton dimention, that is, the electron-hole separation, is large compared to the crystal lattice dimension. Then the Coulomb potential between particles is for isotropic crystals

$$V = \frac{-e^2}{\epsilon r} \qquad (1)$$

where r is the distance between particles, e the electronic charge, and ϵ the dielectric constant. With this potential there will be bound states having energies less than that of the bottom of the conduction band. If, for illustration, we consider the electron and hole masses to be isotropic, the masses are defined in terms of the curvature of the energy bands with wave vector,

$$M^* = \frac{1}{\hbar^2}\left(\frac{\partial^2 E}{\partial K^2}\right)$$

Then the Schrodinger equation can be written in the center of mass system of the pair of particles as

$$\left[-\frac{\hbar^2}{2\mu}\nabla^2 - \frac{e^2}{\epsilon r}\right]\psi = E\psi \qquad (2)$$

here

$$\frac{1}{\mu} = \frac{1}{M_e^*} + \frac{1}{M_h^*} \qquad (3)$$

* This paper, illustrated with slides, was presented at a meeting of the Section on April 19, 1961.

The resultant energy relative to the bottom of the conduction band is of course

$$E_n = \frac{\mu e^4}{2\hbar^2 \epsilon^2} \frac{1}{n^2} \quad (4)$$

Hence if we have direct optical transitions in materials where the effective mass approximation is valid one would expect to observe absorption lines near the absorption edge giving a nearly hydrogenlike series.

The Unixial Symmetry

This idealized model is a convenient starting point for treating real crystals. In particular we know from the studies on the semiconductors germanium and silicon that the effective masses may not be isotropic, the valence band degeneracy introduces mathematical difficulties in separation of the Schrodinger equation into a reduced form and, indeed, for other than cubic crystals, the dielectric constant may be anisotropic. Within the framework of the effective mass approximation, the solution of the exciton problem has been extended to include the possibility of cylindrical symmetry (the Z direction being defined as the symmetry axis) in the hole and electron masses and the dielectric constant. The problem can be solved, including the effect of a magnetic field, by perturbation theory for small anisotropies in the reduced exciton mass and dielectric constant. The starting point for this calculation is equation 20 of Dresselhaus,[3] with the inclusion of a constant magnetic field.

$$H^1 = H^e\left(P + \frac{1}{2}\hbar K + \frac{e}{c}A\right) + H^h\left(P - \frac{1}{2}\hbar K - \frac{e}{c}A\right) + V(r) \quad (5)$$

where $A = \frac{1}{2} H \times r$, K is the wave vector of the exciton. The matrices H^e and H^h are second order in p and written in terms of effective mass tensors as

$$H^e(P) = \frac{1}{2}\sum_{\alpha\beta}\left(\frac{1}{M_e}\right)_{\alpha\beta} P_\alpha P_\beta \quad (6)$$

$$H^h(P) = \frac{1}{2}\sum_{\alpha\beta}\left(\frac{1}{M_h}\right)_{\alpha\beta} P_\alpha P_\beta \quad (7)$$

If one now specializes to cylindrical symmetry assuming a diagonal effective mass tensor, the resultant hamiltonian becomes

$$H = -\hbar^2 \left(\frac{1}{\mu_x}\frac{\partial^2}{\partial x^2} + \frac{1}{\mu_x}\frac{\partial^2}{\partial y^2} + \frac{1}{\mu_z}\frac{\partial^2}{\partial z^2}\right)$$

$$- \epsilon\eta^{1/2}\left(X^2 + Y^2 + \frac{z^2}{\eta}\right)^{1/2}$$

$$- i\hbar\frac{e}{c}\left(\frac{A_x}{\Delta_x}\frac{\partial}{\partial x} + \frac{A_y}{\Delta_x}\frac{\partial}{\partial y} + \frac{A_z}{\Delta_z}\frac{\partial}{\partial z}\right)$$

$$+ \tfrac{1}{2}\beta\sum_{\alpha}\left(\sigma_{e\alpha}S_{e\alpha} + \sigma_{h\alpha}S_{h\alpha}\right) H_{\alpha}$$

$$+ \frac{e^2}{2c^2}\left(\frac{1}{\mu_x}A_x^2 + \frac{1}{\mu_x}A_y^2 + \frac{1}{\mu_z}A_z^2\right)$$

$$- \tfrac{1}{2} i\hbar^2\left(\frac{K_x}{\Delta_x}\frac{\partial}{\partial x} + \frac{K_y}{\Delta_x}\frac{\partial}{\partial y} + \frac{K_z}{\Delta_z}\frac{\partial}{\partial z}\right)$$

$$+ \frac{e\hbar}{2c}\left(\frac{K_x}{\mu_x}A_x + \frac{K_y}{\mu_x}A_y + \frac{K_z}{\mu_z}A_z\right)$$

$$+ 1/8\hbar^2\left(\frac{1}{\mu_x}K_x^2 + \frac{1}{\mu_x}K_y^2 + \frac{1}{\mu_z}K_z^2\right) \quad (8)$$

Each of these terms will be discussed and the resultant solutions indicated. The details of this calculation will appear elsewhere.[4]

The first two terms correspond very nearly to a hydrogenlike system including, however, the mass anisotropy and the effective potential due to the dielectric anisotropy. The effective Rydberg for the problem is defined as

$$R_y = \frac{\mu_x}{\epsilon^2\eta} R_h \quad (9)$$

where μ_x is the exciton-reduced mass in units of the free-electron mass, $\eta = \frac{e_z}{\epsilon_x}$ the dielectric anisotropy, and R_H the atomic hydrogen Rydberg. Then the first two terms of the Hamiltonian can be transformed to that of a hydrogenlike system with a perturbation term due to the anisotropies.

Neglecting the wave vector k of the exciton for the moment, for H = O, Schrodinger's equation for the exciton becomes,

$$-\frac{1}{\mu_x}\frac{\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{1}{Q^2}\frac{\partial^2}{\partial z^2}\right)\Phi_j$$

$$-\frac{e^2}{\epsilon\mu^{1/2}(X^2+Y^2+Q^2Z^2)^{1/2}}\Phi_j+\frac{e^2}{\epsilon\eta^{1/2}}\left[\frac{I}{(X^2+Y^2+Q^2Z^2)^{1/2}}\right.$$

$$\left.-\frac{I}{(X^2+Y^2+\frac{Z^2}{\eta})^{1/2}}\right]\Phi_j=W_j\Phi_j \qquad (10)$$

If the third term on the left is small, the solutions are hydrogenlike with the scale defined by Equation 9 with $Q^2=\frac{\mu_z}{\mu_x}$ and m the free electron mass.

The third term will be treated as a perturbation. The results of this perturbation with the total anisotropy defined in term of

$$\alpha^2=1-\frac{1}{Q^2\eta}=1-\frac{\mu_x\epsilon_x}{\mu_z\epsilon_z}$$

are indicated in FIGURE 1. Here we have included principal quantum number states up to three and all possible orbital angular momenta.

The next three terms are due to the magnetic field. The first of these is the linear Zeeman effect due to orbital angular momenta. The weighting factor of $\frac{1}{\Delta_\alpha}=\frac{1}{Me_\alpha}-\frac{1}{Mh_\alpha}$ arises due to different masses of the continuent parts of the exciton. This perturbation term can be treated conveniently for two cases when the magnetic field is parallel to z and perpendicular to z. Using hydrogenic wave functions the matrix elements for these two cases are

$$\beta\frac{1}{\Delta_x}H_z\,M_i\,\delta ij \qquad H\|Z \qquad (11)$$

$$\beta\frac{1}{\Delta_x}H_x\,\alpha<n_i,\,l_i,\,m_i,\,|\hat{L}_x|\,j_j,\,l_j,\,m_j> \qquad H\perp Z$$

$$-i\beta\frac{1}{\Delta_x}H_x\,b<h_i,\,l_i,\,m_i\,|\,Y\frac{\partial}{\partial z}+Z\frac{\partial}{\partial y}\,|\,n_j,\,l_j,\,m_j> \qquad (12)$$

where β is the Bohr magneton

$$L_x=-i\left(Y\frac{\partial}{\partial z}-Z\frac{\partial}{\partial y}\right)$$

$$\alpha=\tfrac{1}{2}\left(\frac{\Delta_x}{\Delta_z}Q+\frac{1}{Q}\right)\quad;\quad b=\tfrac{1}{2}\left(\frac{\Delta_x}{\Delta_z}Q-\frac{1}{Q}\right)$$

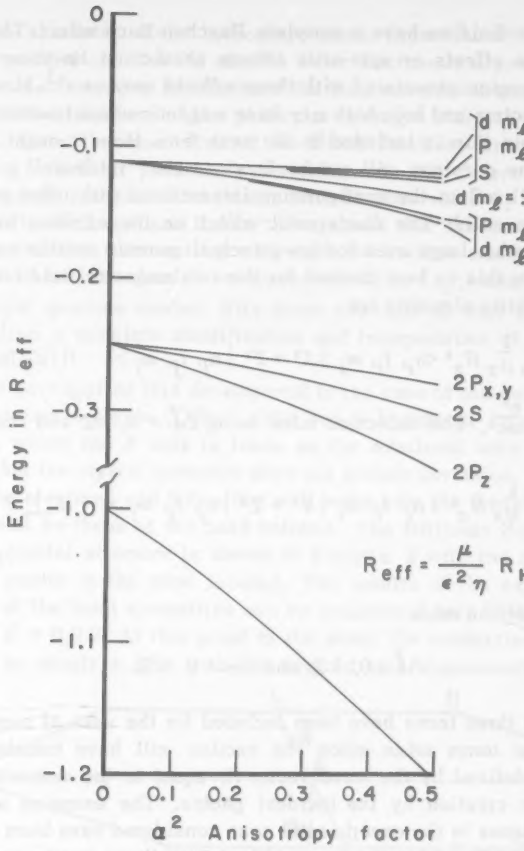


FIGURE 1. Exciton energies as a function of the anisotropy

$$\alpha = 1 - \frac{\mu_x \epsilon_x}{\mu_z \epsilon_z}$$

and n_i, 1_i, m_i are the quantum numbers of the eigenfunctions in question. The selection rules are for L_x $\Delta l = 0$ and $\Delta m = \pm 1$. The operator $Y\frac{\partial}{\partial Z} + Z\frac{\partial}{\partial Y}$ carries the selection rules $\Delta l = \pm 2$, $\Delta m = \pm 1$ when $n = 0$. However when $\Delta n \pm 0$, the selection rules become $\Delta l = 0, \pm 2$ and $\Delta m = \pm 1$.

Since the exciton orbits are very large, indeed relative to a Bohr orbit,

$$a_o^1 = \frac{\epsilon\eta^{1/2}}{\mu} a_o \qquad (13)$$

in a magnetic field we have a complete Paschen-Bach effect. That is, any spin-spin effects or spin-orbit effects should not be observable since the energies associated with these effects vary as r^{-3}. However since the electron and hole both may have magnetic moments associated with their spin this is included in the next term. Here it ought to be noted that the g values will not be 2, since the "intrinsic" g value measured will reflect the configuration interactions with other energy levels in the solid. The diamagnetic effect on the exciton, as will be seen, is rather large even for low-principal quantum number exciton states. Again this is best treated for the two magnetic field orientations. The matrix elements are

$$1/8 r_o \frac{1}{\mu_x} H_z^2 \langle n_i, l_i, m_i \mid X^2 + Y^2 \mid n_j, l_j, m_j \rangle \qquad H \| Z \quad (14)$$

where $r_o = \frac{e^2}{mc^2}$. The selection rules being $\Delta l = 0, \pm 2$ and $\Delta m = 0$, Also

$$1/8\, r_o \frac{1}{\mu_z} H_x^2 \langle n_i, l_i, m_i \mid Y^2 + Z^2 \mid n_j, l_j, m_j \rangle \qquad H \perp Z \quad (15)$$

with the selection rules

$$\Delta l = 0, \pm 2, \text{ and } \Delta m = 0, \pm 2.$$

The last three terms have been included for the sake of completeness. These terms arise since the exciton will have translational momentum, defined by the wave vector K, equal to the momentum imparted upon creation by the incident photon. The energies arising from these terms in the experimental case considered have been shown to be very small, within the line widths.[4] With these matrix elements thus determined[3] the secular determinants can be set up and solved for any state in question. With this formalism, when applied to a spectra of a crystal of known dielectric constants, the experiments will allow one to determine the masses and g values characteristic of the crystal under study.

Exciton Symmetries of C_{6v}^4 Crystals

The energy characteristics are not yet sufficient to interpret an observed spectra. The above formalism has determined the energies relative to the center of mass. In order to determine which of the many possible states can be observed by dipole radiation one must know the symmetry of the total exciton wave function. That is, the symmetry of the exciton state must reflect the symmetry of the crystal as well

as the symmetry of the hydrogenic state. Dresselhaus[5] and others[6,7] have pointed out that the exciton wave function is a product function of the electron wave function and the hole wave function multiplied by the fourier transform of the particular hydrogen state in the center of mass. Since the exact form of the Bloch functions are unknown but, rather, only their possible symmetries, one can determine by group theoretical methods which states will be observable by dipole radiation.[8] Dresselhaus[9] and Haken[6] have shown that the transition probability and thus the oscillator strength for exciton states for allowed dipole transitions should vary approximately as $1/n^3$, being the exciton principal quantum number. With these two aids as well as the energy formalism a complete identification and interpretation of a spectra is possible.

We have applied this development to the case of the exciton spectra of cadmium selenide (CdSe). CdSe has a hexagonal crystal structure C_{6v}^4; where the Z axis is taken as the rotational axis. One should note that the crystal symmetry does *not* include inversion.

The electrons and holes that will enter into the formation of excitons will be those at the band extrema. The Brillouin Zone for hexagonal crystal structure is shown in FIGURE 2 with the special symmetry points in the zone labeled. The results of the experiments in terms of the band symmetries can be understood only if these extrema lie at K = 0,0,0. At this point in the zone, the conduction band symmetry is nearly s like with the twofold spin degeneracy remaining.

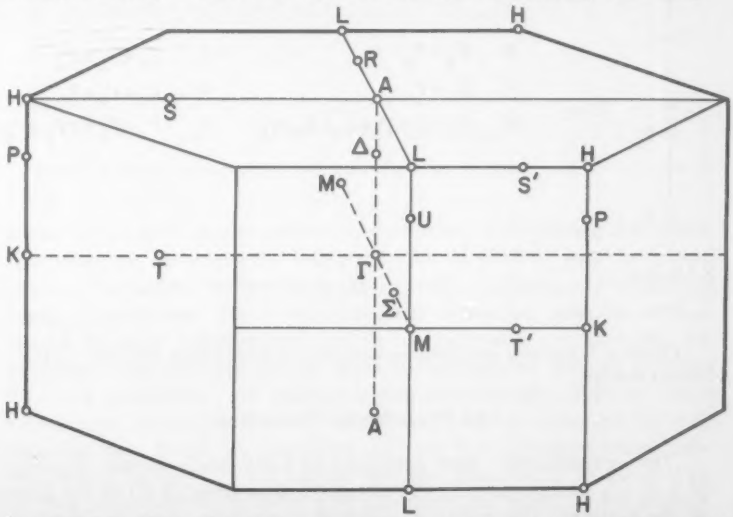


FIGURE 2 The Brillouin Zone for hexagonal crystals. The special symmetry points are labeled.

The valence band exhibits p like symmetry, the sixfold degeneracy (including spin) is lifted due to the crystal field and spin-orbit energies. The result of these interactions is the removal of all orbital degeneracy, only spin degeneracy remaining. An estimate of the order of magnitude of the spin-orbit effect can be obtained from the atomic spin-orbit of selenium; this is of the order of thousands of wave numbers. These considerations are summarized in FIGURE 3. The group theoretical symmetry designations are those of Birman.[10] In FIGURE 3 we have designated the exciton symmetries corresponding to the previously mentioned product functions, considering the two valence band symmetries. In order to determine the dipole selection rules the matrix connecting the ground state of the crystal and a particular exciton state must be invariant under all symmetry operations of the crystal. Since the dipole operator with the electric vector $E \| Z$ transforms as Γ_1, and with the electric vector $E \perp Z$ as Γ_5, only those states designated Γ_1 or Γ_5, will be observed with the corresponding polarization.

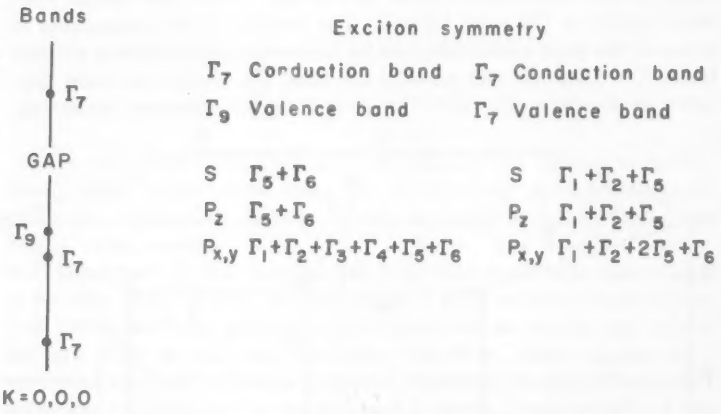


FIGURE 3 Exciton and band symmetries, as compatible with the experimental results.

The Experimental Procedure

The experiments were performed on CdSe single crystal platelets of 1 to 5 μ thickness with the crystal c axis (that is Z) in the plane of the platelet. The crystals, mounted strain free, were immersed in liquid helium at 1.8° K or lower for all experiments. A concave grating

Wadsworth mount spectrograph was used in the second order. The dispersion is about 2.1 A/mm. with a measured resolving power using 103 a-F Kodak Spectrographic Plates of better than 70,000. The magnet was calibrated to better than 0.1 per cent with current stability of the order of 1 part in 10^4. Emission lines from various sources were imposed on each plate for calibration purposes. The spectrum was obtained from the plates by a recording densitometer.

The Experimental Results

FIGURE 4 indicates the anomalous reflection spectra observed near the absorption edge. As shown by Dexter[11] and others, very high oscillator strengths are associated with ground state excitons. Hence

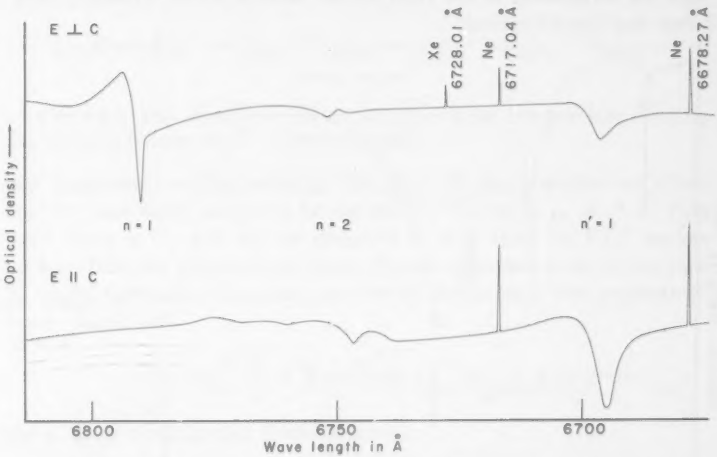


FIGURE 4 The anomalous reflection spectra of CdSe single crystals at 1.8°K

these states give rise to reflection anomalies. Considering the selection rules we associate the reflection peak at 6810 Å with the ground state of the exciton derived from the Γ_9 and Γ_7 valence and conduction bands respectively. Since the anomalous reflection peak at 6710 Å occurs for both polarizations and is of high oscillator strength, we associate this with the ground state of the exciton derived from the Γ_7 - Γ_7 conduction and valence bands respectively. Between these two intense anomalies, smaller reflection peaks are observed for both polarizations. These we associate with the n = 2 excited states corresponding to the Γ_9 - Γ_7 bands; that the observation is allowed in in both polarizations is seen from the selection rules. If we assume that the lighter mass is due to the electron, the Rydberg for the two series will be approximately the same; hence the energy separation of

approximately 210cm^{-1} will correspond to the $\Gamma_9 - \Gamma_7$ valence band splitting. Having identified tentatively the spectra, more accurate energy level determinations and, indeed, Zeeman effect observations can be made in absorption with thin crystals.

FIGURE 5 indicates the absorption spectra for both polarizations. One also observes other lines that cannot be attributed to intrinsic excitons. These lines (unlabeled in the figure) we attribute to impurities in the solid, since the lines are variable from crystal to crystal and all have approximately the same Zeeman splitting with little measurable quadratic Zeeman shift. The line labeled 1_L is the longitudinal exciton having properties as described by Hopfield and Thomas[12] for anisotropic crystals. The intensity is observed to be dependent upon the orientation of the light vector relative to the crystal c-axis; hence this identification.

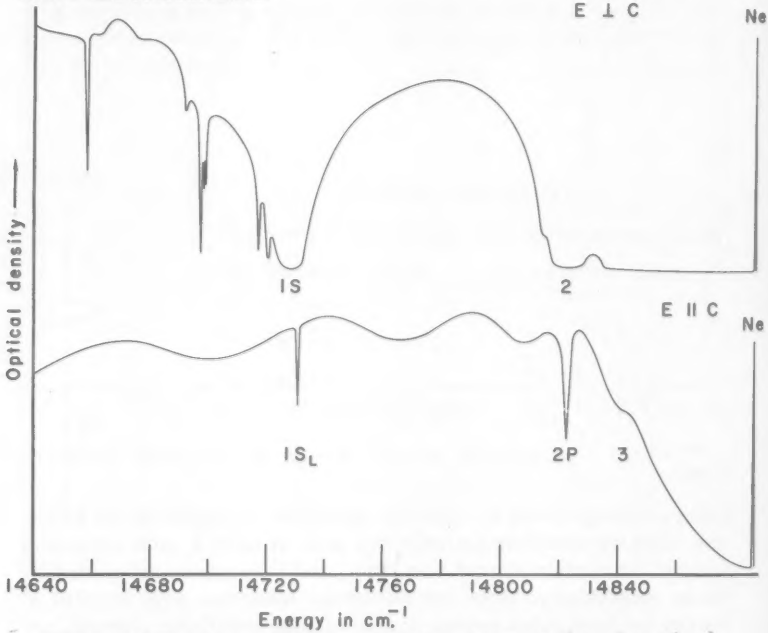


FIGURE 5 The absorption spectra of CdSe single crystals near the absorption edge.

Since the 2p state in $E \| C$ radiation is narrow this line is suitable for Zeeman study. FIGURES 6 and 7 show typical spectra for both orientations of the magnetic field FIGURES 8 and 9 indicate the energies as a function of magnetic field. As is immediately apparent at zero field only the 2 p, $m_l = \pm 1$ state is observable, it splits into

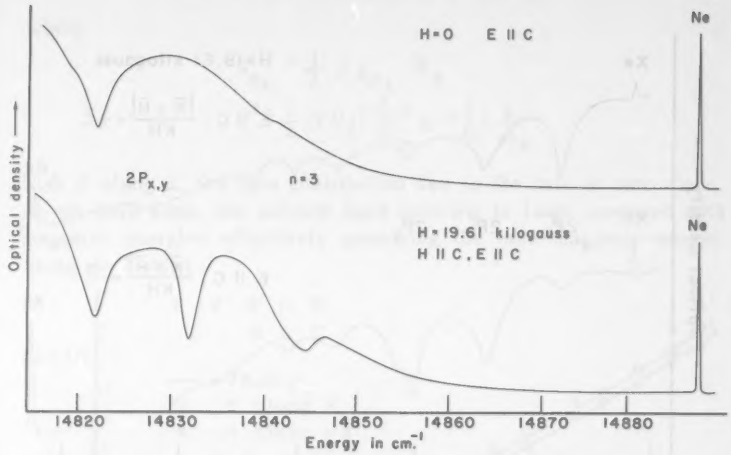


FIGURE 6 The absorption spectra of CdSe single crystals indicating the Zeeman effects upon the $n = 2$ exciton states.

two components without mixing. With $H \perp C$ all the p states mix, allowing the zero field energy to be determined for the 2 p, $m_l = 0$. This state being a Γ_5 will not be observed in zero field for $E \| C$ as can be seen from the infinite wave length dipole selection rules of FIGURE 3. Using the matrix elements previously determined, the energies of these states are

$$E = E_o - \frac{1}{5}\ \delta \pm 12\sigma \pm (\gamma - S_{h_{11}} + S_{e_{11}}),\ H\ 11\ C$$

where E_o is the effective Rydberg energy

$$\gamma = \beta \frac{1}{\Delta_x} H_z$$

$$\delta = \frac{\mu_x}{4\epsilon^2 \eta} \times (R_H \alpha^2) \text{ the anisotropy perturbution}$$

$$\sigma = \frac{1}{4} \pi_o \frac{\epsilon^2}{\mu_x^3} \eta\ a_o^2 H_Z^2 \text{ the diamagnetic effect}$$

$$S_{h_{11}} = \beta H_Z\ g_h,\ S_{e_{11}}$$

$$S_{e_{11}} = \frac{1}{2} \beta H_Z g_e$$

$H \perp C$

$$E_x = E_o + 3(1 + \frac{\mu_x}{\mu_z}\sigma) - \frac{1}{5}\ \delta \mp S_{e_\perp}$$

$$E_\perp = E_o + 6(1 + \frac{\mu_x}{\mu_z})\sigma - \frac{2}{5}\ \delta \pm S_{e_\perp} \pm \left[3(1 - \frac{\mu_x}{\mu_z}) + \frac{\delta}{5}\right]^2 + \gamma^2\Big)^{\frac{1}{2}}$$

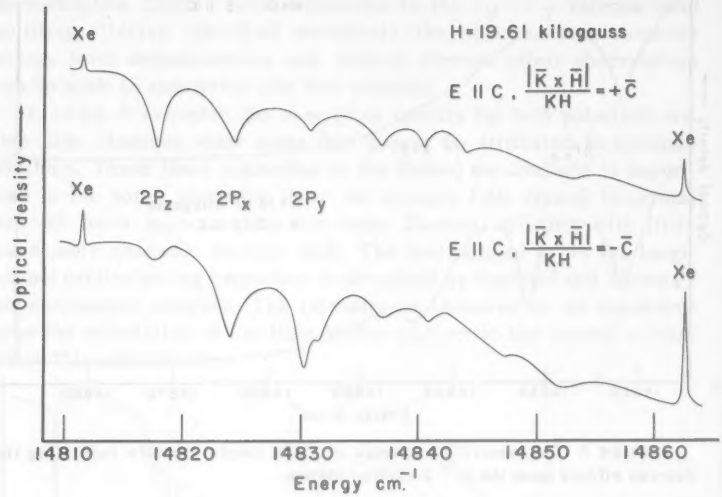


FIGURE 7 See caption for FIGURE 6.

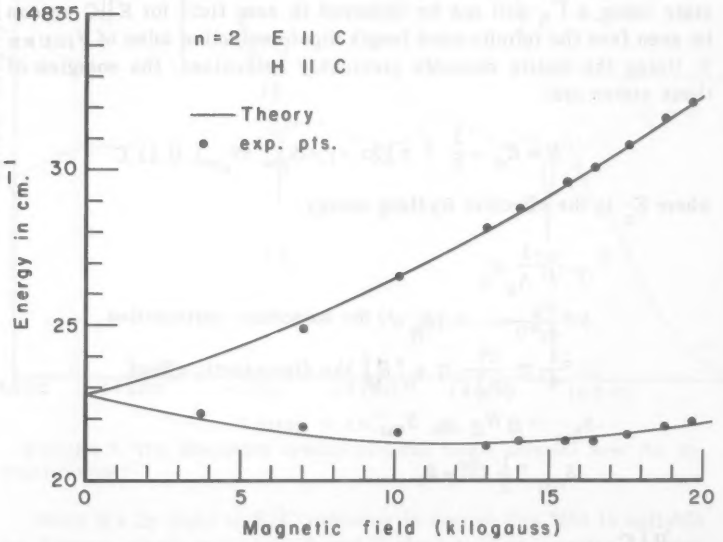


FIGURE 8 The exciton energies in a magnetic field. The theory curve used the data indicated in TABLE 1.

where

$$S_{e_\perp} = \frac{1}{2}\beta g_{e_\perp} H_x$$

$$\gamma' = \frac{1}{2}\beta H_x \left[\frac{\Delta_x}{\Delta_z} g + \frac{1}{Q}\right] \frac{1}{\Delta_x}$$

With H along x, the spin contribution due to the hole is zero since, as we have seen, the valence band splitting is large compared with magnetic energies effectively quenching the hole magnetic moment along the Z axis.

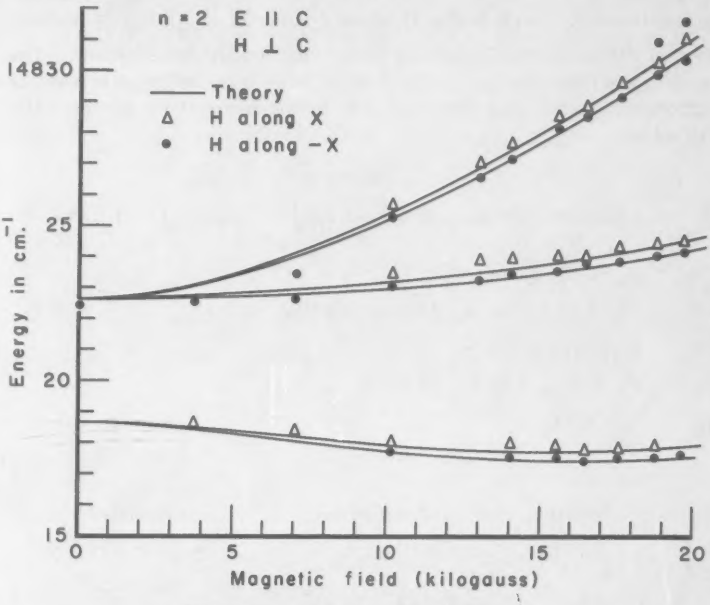


FIGURE 9 See caption for FIGURE 8.

In order to analyze the data and, indeed, test the validity of the theoretical approach the following procedure was adopted. With the magnetic field parallel to the z axis, knowing the dielectric constants to be $\epsilon_x = 9.7$, $\epsilon_z = 10.65$, the reduced effective exciton mass μ can be uniquely determined from the quadratic component of the Zeeman effect. Then using the zero field values for the $2p$ $m_l = \pm 1$ state and the extrapolated $2pm_l = 0$ state we can determine α^2 the anisotropy constant, the effective Rydberg and the series limit. At this point we are in a position to test the validity of our approximation. Since we have measured the energy of the $n = 1$ and the $n = 3$ states, we can compare these with calculated values determined from FIGURE 1.

Further information maybe extracted from the linear Zeeman effect. In the $H||C$ case we can determine the resultant orbital and spin moments. To date we have been unable to observe the splitting of the Γ_5 $2pm_\ell = \pm 1$ state that would permit unambiguous determination of all g-values. However, we also observed no splitting of the 1_L longitudinal exciton. This state of spherical symmetry has the same spin configuration as the observable *p*-state exciton. From the line width we place an upper bound of $|g_e - g_h| \leq 1.0$. Hence this allows the determination of the electron and hole effective masses, the error due largely to the indeterminacy of the spin contribution. In the $H \perp C$ case, the small linear splitting is the electron g value of $|g_{ex}| = 0.45$. We can further determine the anisotropy in the electron and hole masses. The results are tabulated in TABLE 1. The large error in the hole mass is introduced, since the energies are rather insensitive to the hole anisotropy.

TABLE 1

PARAMETER DETERMINED FROM $2pm_\ell = 0$ AND $2pm_\ell = \pm 1$ DATA

$\mu_x = 0.105 \pm 0.003\ M_e$

$\alpha^2 = 0.34 \pm 0.03$; $\mu_z = 0.145 \pm 0.015\ M_e$

$R_{eff} = 111 \pm 2\ \text{cm.}^{-1}$

$E_\infty = E_{g\,ap} = 14852 \pm 2\ \text{cm.}^{-1}$

$a_o' = 53\text{Å}$

State	Experimental	Calculated
1S	$14727 \pm 1\ \text{cm.}^{-1}$	$14727 \pm 0.4\ \text{cm.}^{-1}$
$2_{p,}\ M_1 = \pm 1$	$14822.5 \pm .\ \text{cm.}^{-1}$	
$2_{p,}\ M_l = 0$	$14818.6 \pm 0.3\ \text{cm.}^{-1}$	
3	$14839 \pm 1\ \text{cm.}^{-1}$	$14838.9 \pm 1\ \text{cm.}^{-1}$

MASS PARAMETERS

$M_{ex}^* = 0.132 \pm 0.006\ M_e$

$M_{ez}^* = 0.145\ {}^{+\ 0.03}_{-\ 0.02}\ M_e$

$M_{hx}^* = 0.5 \pm 0.1 M_e$

$M_{hz}^* > 1\ M_e$

$M_{ez}^x = 0.145\ {}^{+.03}_{-.02}$

The variation in intensity with $H \perp C$ upon rotation of the magnetic field 180 degrees has the following quantitative explanation. One would not expect this effect due to time reversal invariance if the exciton has zero wave vector. That such a variation exists must be due to the finite wave length of the light. That which remains invariant under time reversal is

$$\frac{\bar{K} \times \bar{H}}{|K \times H|}$$

The absence of inversion symmetry specifies a unique axial direction. This suggests that if one only reverses the magnetic field, $H \rightarrow -H$, a change may occur. However, time-reversed $K \times H = (-K) \times (-H)$ is invariant under crystal symmetry, suggesting that both field and light vector reversal will produce the original spectra. Indeed the experiments performed bear this out. The explanation of this effect in uniaxial crystals was first proposed for the spectra of cadmium sulfide by Hopfield and Thomas [13].

The Anomalous g values

The g factor of conduction electrons can differ from that of free electrons due to coupling with valence band electrons. If the spin orbit splitting of the valence band is comparable with, or larger than, the energy gap between conduction and valence bands the g values maybe quite anomalous. This problem has been treated in detail by Yalet [14], Luttinger [15], Cohen [16], and Roth. [17] Roth has calculated the effect for conduction electrons at $K = 0,0,0$, for Ge and Si. We have used that formalism to estimate, from the g values and masses measured experimentally, that the spin-orbit splitting of the valence band is of the order of 5000 $cm.^{-1}$ This calculation will be published elsewhere. [4]

Acknowledgments

We thank Richard Bube of the RCA Laboratories for supplying the crystals used in this work, and D. Berlincourt of the Clevite Laboratories for use of the dielectric constant data before its publication.

References

1. MOTT, N.F. 1938. Trans. Faraday Soc. **34**: 500.
2. WANNIER, G.H. 1937. Phys. Rev. **52**: 191.
3. DRESSELHAUS, G. J. 1956. Phys. Chem. Solids. **1**: 15.
4. WHEELER, R.G. & J.O. DIMMOCK, Phys. Rev. To be submitted.
5. BETHE, H.A. & E.E. SALPETER. 1957. Quantum Mechanics of One and Two Electron Atoms. Academic Press. New York, N.Y.
6. HAKEN, H. 1959. Proceedings of the Third International Conference on Semi-Conductors (1958). Pergamon Press, London, England.
7. HOPFIELD, J. J. & D. G. THOMAS. 1960. J. Phys. Chem Solids. **12**: 276.

8. HEINE, V 1960. Group Theory in Quantum Mechanics. Pergamon Press. London, England.
9. DRESSELHAUS, G. 1957. Phys Rev. **106**: 76.
10. BIRMAN, J.L. 1959. Phys. Rev. Letters. **2**: 157.
11. DEXTER, D.L. 1953. J. Chem. Phys. **21**: 836.
12. HOPFIELD, J.J. & D.G. THOMAS. 1960. Phys. Rev. Letters. **4**: 357.
13. YAFET, Y. 1952. Phys. Rev. **85**: 478; Phys. Rev. **106**: 679.
14. LUTTINGER, J.M. 1956. Phys. Rev. **102**: 1030.
15. COHEN, M.H. & E.I. BLOUNT. 1960. Phil. Mag. **50**: 115.
16. ROTH, L. M. 1960. Phys. Rev. **118**: 1534

DIVISION OF MICROBIOLOGY

FIELD STUDIES ON SANDFLY FEVER AND KALA-AZAR IN PAKISTAN, IN IRAN, AND IN BALTISTAN (LITTLE TIBET) KASHMIR*

Herbert C. Barnett and William Suyemoto

Division of Communicable Disease and Immunology, Walter Reed Army Institute of Research, Washington, D. C.

Sandflies are uncommon insects in the United States and none of the American species is of demonstrated medical importance. In other areas of the world, however, species of the genus *Phlebotomus* play an important role as vectors of several human and animal pathogens. Our studies have been confined to sandfly fever, a human disease of viral etiology, and to the leishmaniases, zoonoses caused by protozoan parasites. The field investigations were carried out during 1959 and 1960 in Pakistan, in Iran, and in Baltistan or Little Tibet, an extremely mountainous frontier district of the state of Kashmir, and these have been followed by laboratory studies in Washington, D. C.

Some basic biological information on sandflies and the diseases they transmit is required as background for an understanding of these studies. Sandflies are true flies of the family Psychodidae and the Old World forms are divided into two genera, *Phlebotomus* and *Sergentomyia*. They are small dusty-colored insects, considerably smaller than mosquitoes and rather hairy in appearance (FIGURE 1). The females are fitted with piercing and sucking mouthparts that enable them to suck blood from a variety of animals including man. The males do not suck blood, but presumably feed on nectar or plant exudates. The adults are most active in the hours between sunset and dusk, and many species readily enter houses in search of blood meals. Like other members of the order Diptera, the sandflies have four stages in their life cycle: the egg, the larva, the pupa, and the adult. Unlike mosquitoes, they do not breed in aquatic environments. The females lay their eggs in cracks and crevices filled with organic matter, admidst rubble and heaps of rocks, and sometimes in cracks deep in the soil.

Sandflies are known to carry three groups of diseases: the sandfly fevers, the leishmaniases, and the bartonelloses. The last-named group of diseases will not be discussed in this paper. Sandfly fever (pappataci fever) is one of the most widely distributed of the sandfly-borne diseases, at least in arid areas of the Old World. It is a 3- or 4-day fever clinically similar to influenza except for the absence of respiratory symptoms. The incubation period varies from 3 to 6 days, but usually is only 3 or 4 days. While the clinical course of the disease varies from

*This paper was presented at a meeting of the Division on April 21, 1961.

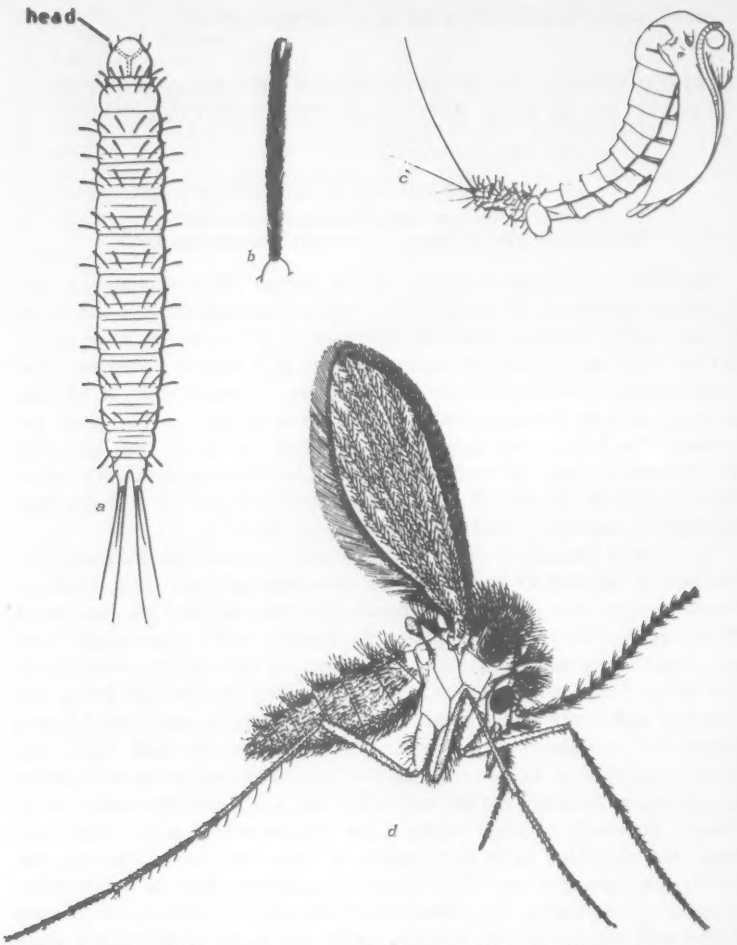


FIGURE 1. *Phlebotomus papatasi* (after Smart) (*a*) larva, (*b*) larval hair, (*c*) pupa, and (*d*) adult female.

mild to moderately severe, death is unknown. The disease is difficult to distinguish from a number of other mild febrile illnesses including dengue, West Nile fever, various fevers of undetermined origin and, occasionally, even influenza and the common cold. Laboratory procedures offer little diagnostic help to the physician at present. Occurrence of the disease varies from sporadic cases in endemic situations to outbreaks of great magnitude. The latter situation is illustrated by the sudden appearance of sandfly fever in Serbia during 1946, when epidemics

involving as much as 90 per cent of the population of some towns occurred. In the northern part of Serbia, where the epidemics broke out in 1948, approximately three fourths of its population (1,200.000) came down with the disease (D. Guelmino and M. Jevtic, 1955).

The leishmaniases constitute a second group of sandfly-borne diseases of considerable importance and include three clinical entities: visceral leishmaniasis or kala-azar, Old World cutaneous leishmaniasis or Oriental sore, and New World cutaneous leishmaniasis. Kala-azar is a very serious infection, caused by *Leishmania donovani*. It is characterized by irregular fever of long duration, chronicity, anemia, and progressive emaciation, and it frequently terminates in death in untreated cases. It is commonly confused with malaria, but laboratory procedures permit rapid differentation. It is essentially a rural disease with a broad distribution through Asia, the Middle East, Europe, Africa, and South and Central America. Old World cutaneous leishmaniasis, caused by *Leishmania tropica*, occurs in Asia, the Middle East, the Mediterranean littoral, and Africa, while New World cutaneous leishmaniasis, caused by *Leishmania brasiliensis*, is distributed through South and Central America. Both cutaneous diseases are characterized by superficial infections producing nodular and ulcerating lesions on exposed portions of the body. In Latin America the lesions frequently are more ulcerative, often involving mucous membranes and causing extensive necrosis of the nose, mouth, and pharynx.

The foregoing brief review of sandfly-borne diseases is necessarily restricted to the "knowns". There are several facets of each of these diseases about which little is known, Sabin (1951) demonstrated that sandfly fever could be caused by either of two immunologically distinct strains of virus: the Sicilian and the Naples strains. Sabin's two strains were obtained from a series of three isolates from patients, all from cases that occurred in the Mediterranean area. Had the number of virus isolates been larger or had isolates been obtained over a broader geographic area, it is entirely possible that additional immunologically distinct virus strains would have been recognized. Thus one is led to speculate that sandfly fever might possibly represent a complex of infections caused by several distinct viruses, as has been demonstrated recently in dengue.

The sandfly, *Phlebotomus papatasi* has been associated with sandfly fever since the turn of the century, but it is not known if other sandflies serve as vectors. *P. papatasi* is a domestic (house-haunting) species and it is safe to presume that much, if not most, of the disease it transmits occurs in villages and in urban environments. It is not known if any of the sandfly species that live and breed in open country also transmit these viruses. From available information, man and the sandfly have appeared to be the only possible reservoirs of disease. Petrischeva (1954) has reported sandfly fever in travelers in the desolate,

uninhabited Kara Kum Desert of the Turkmenistan-Iran border region. This occurrence of disease in an area where humans are not resident is considered evidence of the involvement of animal reservoirs, but no evidence has been obtained incriminating any particular animal or group of animals. Some investigators (H.E. Wittingham, 1924; S.D. Moshkovsky *et al*, 1937) have reported transovarian transmission of virus in sandflies, but Sabin (1951) was not able to confirm this. Should transovarian passage of virus occur, this mechanism could explain the manner in which virus passes the winter in temperate areas.

There are also a number of unknowns in the field of immunity. Multiple attacks of sandfly fever during a single season in 15 to 20 per cent of infected individuals and the abrupt cessation of such attacks with the disappearance of adult *Phlebotomus* has been observed by numerous workers. Sabin (1951) has observed multiple cycles of fever in 4 of 100 cases of experimentally produced disease following a single inoculation of virus in each case. He has summed up the problem as follows: "It is difficult to interpret the significance of presumable repeated attacks in individual patients when one is dealing with a disease for which there is no specific clinical-identifying sign or laboratory test. Thus one is faced with several alternative explanations: (a) it is possible that one or both attacks of the natural disease diagnosed as sandfly fever, was not sandfly fever, (b) immunity to sandfly fever may not persist, or (c) that multiple immunological types of the virus may be involved." To confuse the situation further, there are numerous observations that "seasoned" troops and long-term residents of an endemic area are immune to infection.

In 1959 we began our field studies with three principle objectives: (1) to isolate the virus from febrile patients and from wild-caught sandflies to determine the spectrum of immunological types of virus, and to determine the species of *Phlebotomus* involved in their transmission; (2) to search for evidence of animal reservoirs by collecting sera from a variety of wild and domestic animals in endemic areas for serologic study; and (3) to establish a colony of *Phlebotomus papatasi* to provide material for transmission studies on known sandfly fever viruses and to assist in the definition of any new virus isolates as sandfly fever agents by demonstration of their transmissibility through sandflies.

The studies were initiated in West Pakistan and Iran (FIGURE 2) because it was known that sandfly fever and its sandfly vectors were both endemic and abundant in these countries. In West Pakistan our studies were centered in the Rawalpindi and Peshawar (Khyber Pass) areas. Sandfly fever has been studied previously in the latter area (T. C. Young *et al*, 1926). The Varamin Plains area immediately to the southeast of Teheran served as the study area in Iran. In both the Khyber Pass and Varamin Plains areas the disease appears to be quite common in young children but much less so among adults. Sandflies, particularly *P. pa-*

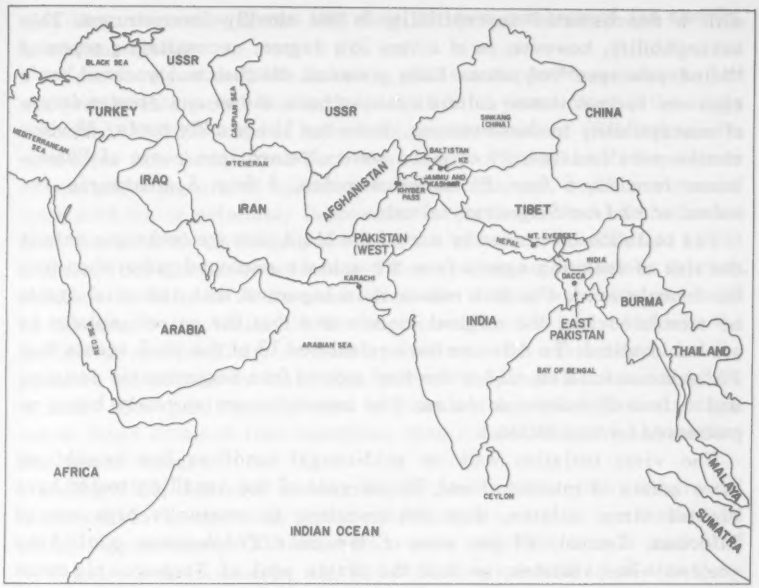


FIGURE 2. Sketch map of study area.

patasi, are extremely abundant in both areas. It is our interpretation that infection is acquired in infancy or early childhood, and that the resultant immunity is reinforced annually by superimposed inapparent infections, thus "eliminating" the disease from the indigenous adult population. However, when susceptible adults intrude into such areas, they acquire the disease and, if their numbers are large enough, explosive epidemics occur (T. C. Young *et al*, 1926)

During 1959, 66 sera were obtained from febrile patients with clinical disease resembling sandfly fever. From these sera F. R. McCrumb of the University of Maryland School of Medicine, College Park, Md. has isolated 8 viruses, 4 of which were reisolated from the original inocula. Four of the isolates were obtained from patients in Pakistan and four from patients in Iran. One of the isolates from Pakistan and three from Iran have been identified as the Sicilian strain of sandfly fever; the remainder have not been fully characterized or identified but appear to be new, previously undescribed viral agents.

The 1959 field studies also yielded approximately 13,000 wild-caught sandflies of the genera *Phlebotomus* and *Sergentomyia* for virus isolation. This sandfly material was divided into 114 pools by genus and sex, and processed in the usual manner for the isolation of arthropod-borne viruses. Suspensions of each of these pools were inoculated intracerebrally into litters of suckling white mice, as this is the only laboratory animal

with a demonstrated susceptibility to the sandfly fever viruses. This susceptibility, however, is of a very low degree, necessitating repeated "blind passages" of mouse brain material. Neither embryonated hen's eggs nor various tissue culture systems have shown any greater degree of susceptibility to these viruses. From the 114 sandfly pools, 39 virus strains were isolated; 29 of these were obtained from pools of *Phlebotomus* females, 6 from *Phlebotomus* males, 3 from *Sergentomyia* females, and 1 from *Sergentomyia* males.

The isolation of viruses by use of the blind-passage technique entails the risk of isolating agents from the animals employed rather than from the inocula used. For this reason it is important that new viral agents be reisolated from the original inocula and that the paired isolates be proved identical. To date, we have reisolated 13 of the viral agents from *Phlebotomus* females, all 3 of the viral agents from *Sergentomyia* females, and 5 from *Phlebotomus* males. The remainder are currently being reprocessed for reisolation.

The virus isolation work on wild-caught sandflies has brought out three points of interest. First, 34 per cent of the sandflies tested have yielded virus isolates, thus demonstrating an unusually high rate of infection. Second, 29 per cent of the male *Phlebotomus* pools have yielded virus isolates, as has the single pool of *Sergentomyia* males tested. The unusually high rate of virus infection in sandflies and the repeated recovery of viruses from male pools constitute very strong suggestive evidence of transovarian transmission of virus. Finally, the recovery of viruses from *Sergentomyia* females provides the first evidence of the possible role of this group of flies as vectors of viral pathogens.

Thus far we have identified 1 of the 39 isolates from sandflies as the Sicilian strain of sandfly fever virus. The remaining 38 isolates have not been fully characterized or identified. The remarkable growth of virus taxonomy during the past 10 to 15 years has made the identification of new arthropod-borne viruses a very complex and difficult task. The number of arthropod-borne viruses now approximates 150, and new ones are being described almost monthly. Almost all of the isolates from sandflies and the 4 unidentified agents from patients are poorly adapted to mice and have very low titer, even after as many as 30 mouse passages. Furthermore, they possess very poor antigenicity, and we have not succeeded thus far in producing satisfactory antisera. None has yielded satisfactory hemagglutinins for employment in hemagglutination inhibition tests. We have attempted to group these agents by vaccination cross-challenge tests, but the results have been equivocal. Currently, efforts are being made to prepare antisera through the use of adjuvants. On the basis of available information, it appears that most of these viral isolates are new, undescribed viruses, and their behavior in laboratory animals and in tissue culture, together

with their source, suggests that they are new members of the sandfly fever virus group.

As previously stated, the taxonomy of the arthropod-borne viruses has made remarkable growth during the past 10 to 15 years. Many of the newly described ARBOR viruses have been isolated solely from arthropods, most often from mosquitoes. Such viruses are of questionable importance as causative agents of human and animal disease, until evidence of their medical or veterinary importance is obtained. We have before us then, the problem of relating the viral isolates from sandflies to human disease. Work with human volunteers is an obvious but hazardous solution. Sera from inhabitants of the areas where the viruses were obtained could be surveyed by neutralization or complement fixation tests, but here the problem of nonspecificity or crossing is frequently encountered, and the presence of antibodies could also reflect inapparent or subclinical infection. With good fortune, virus isolates obtained from patients might match those obtained from sandflies, thus establishing the association with human disease.

During 1959, 340 sera were collected from healthy young adults and from children in the study areas of Pakistan and Iran for serological study. Approximately 200 sera also were collected from a variety of wild and domestic animals and birds. Serological testing of these materials have been postponed pending further characterization and identification of viral agents from patients and sandflies.

The colonization of *P. papatasi* was initiated by collecting blood-engorged females in large numbers, placing them individually in specially prepared vials and collecting the eggs that were deposited in them. The eggs were then shipped by air to Washington D. C., where the larvae were reared on a mixture of pulverized manure, dried blood, and humus. A colony was established and maintained for five generations, before it was wiped out by a mite infestation.

By the spring of 1960, it was apparent that we could not maintain our colony of *P. papatasi*. Opportunities for research studies on the leishmaniases also manifested themselves at this time. As previously indicated, there are three distinct clinical leishmanial infections recognized: kala-azar, Old World cutaneous leishmaniasis, and New World cutaneous leishmaniasis, caused by *L. donovani, L. tropica* and *L. brasiliensis*, respectively. While the designation of these leishmanial forms as three distinct species has been convenient taxonomically, they are not clearly distinguishable by morphological criteria, by cultural characteristics, by serology, by cross-immunity, by their behavior in laboratory animals following inoculation, or by their behavior in various sandfly species. In fact, these three "species" are clearly separated only on the basis of the disease they produce in man (Kirk, 1947). As a consequence, a theory of leishmanial unity has been advanced (C. A. Hoare, 1949; A. Mohiuddin, 1952). We are very much in-

clined toward this theory of leishmanial unity, but carry it a step further. We have hypothesized that the pathogenic characteristics of *Leishmania*, including their ability to cause various clinical syndromes in man, are conferred upon them by the particular species of sandflies with which they are associated. Our arguments for this hypothesis are as follows: (1) the geographic distribution of each of the leishmanial diseases is more or less distinct, with little overlapping; (2) these geographic distributions are largely confluent with the distribution of various sandfly species; (3) in laboratory induced infections of animals, *L. donovani* sometimes produces purely cutaneous lesions, while *L. tropica* and *L. brasiliensis* very commonly produce visceral infections, indicating that the pathogenic characteristics of species are not fixed; and (4) culture of *Leishmania* brings about a very rapid loss of pathogenicity, which can be restored almost immediately by passage of culture material through sandflies.

The primary objective of our most recent field trip was to collect the materials necessary to test this hypothesis. Fresh cultures from patients with dermal leishmaniasis and kala-azar were desired, as well as a colony of *Phlebotomus argentipes*, the vector of kala-azar in the Indian subcontinent. It was also desired to reestablish a colony of *P. papatasi* for studies on both the leishmaniases and sandfly fever.

Shortly after our arrival in Pakistan in the summer of 1960, we learned that some of our Pakistani colleagues at the Armed Forces Institute of Pathology in Rawalpindi had located a new focus of kala-azar (Nur Ahmad *et al. 1960*). Investigating reports of an unusual and unidentified disease in Baltistan, they demonstrated a number of cases of kala-azar by finding the causal parasite. These findings were of more than usual interest. The valleys of Baltistan in which these cases were found lie at elevations between 7,700 and 8,400 feet. Almost all of the areas in the Indian subcontinent where kala-azar is endemic lie at elevations of less than 2,000 feet. Kala-azar had not been reported from this area previously, although 12 cases had been reported from elsewhere in Kashmir (V. P. Jacob and S. L. Kalra, 1951). We visited this remote area in the heart of the Himalayas in September of 1960 and confirmed the occurrence of kala-azar. The epidemiological pattern of the disease appears to resemble that of Chinese kala-azar because cases seem to be restricted to children, in contrast to the classical kala-azar of the Indian subcontinent, which attacks all age groups. Sandfly collections in Baltistan consisted mainly of two species, *Phlebotomus chinensis* and *Phlebotomus kandelakii*.* Either of these species could be serving as the vector in Baltistan. *P. chinensis* is known to be the important vector of kala-azar in China, while *P. kandelakii* is a member of the so-called *major* group, which includes many of the demonstrated vector

*We are indebted to D. J. Lewis, Medical Research Council, London, England, for assistance in the identification of sandflies collected during these studies.

species. Cultures of the Baltistan strain of kala-azar have been obtained, but insufficient sandfly material was available at the time of our visit to permit colonization of the two species under suspicion.

A colony of *P. papatasi* has been reestablished in Washington and, through the courtesy of S. M. Ghosh of the Calcutta School of Tropical Medicine, Calcutta, India, a colony of *P. argentipes* also was obtained. These colonies, together with the various strains of *Leishmania* we have been collecting, place us in a position to undertake experimental studies on the factors affecting the pathogenic characteristics of *Leishmania*.

In conclusion, we should like to sound an optimistic note on the future public health importance of the sandfly-borne diseases. Sandflies are extremely susceptible to DDT and other residual type insecticides. In our studies in the Varamin Plains area of Iran, we observed that villages that had been sprayed within the past two years had few if any sandflies, whereas sandflies were abundant in unsprayed villages and in villages sprayed over two years previously. Therefore, it appears that a single residual spraying of a village will render it free of sandflies for two years. Moreover, the sandflies are the only group of medically important arthropods in which insecticide resistance is still unreported. It seems reasonable to expect that effective malaria-control programs, based on residual spraying, will bring about, as a by-product, the control of sandfly-borne diseases.

References

GUELMINO, D. & M. JEVTIC. 1955. An epidemiological and hematological study of sandfly fever in Serbia. Acta Tropica, 12: 179-182.

HOARE, C. A. 1949. Handbook of Medical Protozoology: 157-158. Bailliere, Tindall & Cox., London, England.

JACOB, V. P. & S. L. KALRA. 1951. Kala-azar in Kashmir. Indian J. Med. Research. 39: 323-327.

KIRK, R. 1947. The differentiation and nomenclature of *Leishmania*. Parasitology. 38: 263-273.

MOSHKOVSKY, S. D., N. A. DEMINA, V. D. NOSINA, E. A. PAVLOVA, L. M. LIVSHITZ, G. Y. PEL'S & V. P. RUBTZOVA. 1937. The transmission of the virus of pappataci fever by *Phlebotomus* hatched from eggs laid by infected females (In French). Med. Parazitol. (Moscow). 6: 922-937.

NUR AHMAD, M. I. BURNEY & YAQUB WAZIR. 1960. A preliminary report on the study of Kala-azar in Baltistan (West Pakistan). Pakistan Armed Forces Med. J. 3: 1-10.

PETRISCHEVA, P. A. 1954. Bloodsucking insects and ticks in the Kara Kum and their medical importance in the rehabilitation of deserts (In Russian). Zool. Zhur. 33: 243-268.

SABIN, A. B. 1951. Experimental studies on Phlebotomus (pappataci, sandfly) fever during World War II. Arch ges. Virusforsch. (Vienna). 4: 367-410.

WHITTINGHAM, H. E. 1924. The etiology of Phlebotomus fever. J. State Med. 32: 461-469.

YOUNG, T. C. M., A. E. RICHMOND & G. R. BRENDISH. 1926. Sandflies and sandfly fever in the Peshawar district. Indian J. Med. Research. 13: 961-1021.

DIVISION OF ANTHROPOLOGY

A RE-EXAMINATION OF NORTHWEST COAST ECONOMIC SYSTEMS*

Andrew P. Vayda

Department of Anthropology, Columbia University, New York, N. Y.

The potlatching and associated practices of the Indians of the Northwest Coast of North America have been characterized by scholars as topsy-turvy (Herskovits, 1952, pp. 415 and 476), nonadaptive (Dice, 1955, pp. 223 to 224 and p. 273), nonfunctional (Linton, 1955, p. 52), absurdly wasteful (Benedict, 1934, pp. 190ff., 247), and little related to problems of livelihood (Goldman, 1937, p. 180; White, 1959, pp. 240 to 241). A new perspective from which the customs in question may be viewed is provided by a study of the Coast Salish socioeconomic system recently published by Wayne Suttles (1960). The perspective is important as well as new, for it suggests that conclusions about the nonadaptive or nonfunctional character of Northwest Coast economic systems are premature and may indeed be entirely unwarranted. This is a matter to which I shall return in my concluding remarks. I shall now summarize some salient features of Suttles' interpretation of the socioeconomic system of the Coast Salish Indians of Southern Georgia Strait and the Strait of Juan de Fuca.

(1) There were exchanges of relatively perishable foodstuffs for durable "wealth" or prestige goods between Coast Salish village communities. People in one community took food to their affinal relatives in another and received wealth (such as blankets, shell ornaments, hide shirts, and fine baskets) in return.

(2) A main incentive, or personal motivation, for giving foodstuffs and getting wealth seems to have been the desire to get enough wealth so that prestige might be acquired by dispensing that wealth.

(3) In the Coast Salish area under consideration, there were significant variations from place to place and from time to time in just how effective food production was. This meant that community A at some given time might be able to get more food than it could consume by itself, while community B at the same time might be short of food supplies. At some other time, community B might have the "superabundance" while community A experienced a shortage. Because of such variations, the intercommunity food-for-wealth exchanges might well have been advantageous in the long run for the communities involved.

(4) It may be assumed that in certain short runs (for example, in periods of two or three years) some particular communities might have considerably more success than others in the production of food that

* This paper was presented at a meeting of the Division on April 24, 1961.

could be taken elsewhere in return for wealth. There would be this differential success if food production in some of the communities, but not others, were disturbed or kept low by such conditions as bad weather, bad salmon runs, and warfare. The effect of the differential success in food production would be differences among communities in the amounts of wealth accumulated.

(5) Potlatching by a community consisted of feasting the members of other communities and distributing wealth to them. The motivation to potlatch in order to gain or validate prestige and status appears to have been fairly constant and therefore cannot be used to explain why there was potlatching at one time and place and not another. To explain this, the amount of wealth in the community seems more relevant. A community had to have a certain accumulation of wealth before it could potlatch, and the likelihood of potlatching by the community would increase as the amount of wealth in the community increased.

(6) Potlatching had the effect of redistributing wealth among communities involved in the food-for-wealth exchanges. In other words, the potlatches tended to reduce inequalities in the possession of wealth among communities. This meant that the incentive to produce food and perhaps to maximize food production in order to get wealth and prestige could continue. People could go on acquiring wealth by producing foodstuffs in one community and taking them to other communities.

The emphasis in Suttles' interpretation, as in the summary that I have just given, is on the *intercommunity* rather than *intracommunity* distribution of goods. The latter was, however, related to the former. Persons or families receiving food from members of other communities invited members of their own community to partake of the food at feasts (Suttles, 1960, p. 298). Thus the movement of food from one community to another did not lead to major inequalities in the distribution of food within the receiving community.

It must be said that while this is made clear enough by Suttles, he does not give an adequate account of the distribution of food within the giving rather than the receiving community. Informants are cited to the effect that a man could at any time take food to affinal relatives in another locality (Suttles, 1960, p. 298). However, can we be sure that this was so? Could or would a man take food to affinal relatives in another community at a time when some members of his own community were very short of food? It seems likely that some sanctions were operating to prevent this from happening very often. Suttles (1960, p. 298) states that a person taking food to another community invited members of his own local group to help him transport it. This suggests that any food-taking expedition was a somewhat public affair among the Coast Salish and that if there were strong feelings that the food should be kept within the home community, there would have been the means and opportunities for expressing these feelings. Moreover, to *give* food away to community

members was a moral action in return for which a person could expect prestige (Suttles, 1960, p. 299). If a man could get prestige directly from members of his own local group in return for food, he might be less inclined to try to get it from them by taking the food to another place, getting wealth in return, and then dispensing that wealth in order to gain prestige within his community.

These considerations suggest that people might have tended to take food to another community not at any time and not whenever they themselves had some kind of surplus but rather only when the community as a whole had some kind of surplus. When the community as a whole had this, it was in its interest to have food taken elsewhere in return for wealth. The wealth acquired could gain prestige not only for individuals eventually dispensing the wealth or contributing it to some community occasion, but also for the entire community when it was the host at a potlatch. Moreover, if the wealth failed to be used in potlatching, it might still serve to attract food bringers to the community at future times. Furthermore, as mentioned before, any food brought was distributed among community members. Additional research needs to be done on the relation between the intracommunity and intercommunity distributions of goods.

In general, the re-examination of Northwest Coast economies begun in 1959 by Suttles, by myself, and by our students at the University of British Columbia is still in a preliminary stage. However, a picture of self-regulating systems in Northwest Coast economies other than the Coast Salish economies is beginning to emerge. By way of illustration, I shall refer briefly to some of the findings and interpretations made by a former University of British Columbia student, Stuart Piddocke (1960), regarding the Kwakiutl economic system.

The chief subsistence activities of the Kwakiutl Indians were sea fishing, river fishing, berry picking, and the hunting of land and sea mammals. It is clear that the amounts of food resulting from these activities varied from place to place and from season to season. Piddocke, however, cites evidence of not only seasonal and local but also considerable year-to-year variation in food production, a kind of variation that has an importance perhaps not so obvious to students who speak of the Kwakiutl's "fantastic surplus economy" and their "production far in excess of subsistence requirements" (Codere, 1950, pp. 14, 63; cf. Benedict, 1934, p. 173; Codere, 1950, p. 4). That the fantastic surpluses and the production far in excess of subsistence requirements may have been only occasional rather than regular features of Kwakiutl economics is indicated by varied data. For example, we may cite the considerable year-to-year variation shown in the statistics on herring spawning in British Columbia coastal waters (Outram, 1956, 1957, 1958) and in the statistics on the packs of canned sockeye and other salmon taken at

Rivers Inlet in Kwakiutl territory from 1882 to 1954 (Cobb, 1921, pp. 171 to 174; Godfrey, 1958*a*, p. 333). Recent investigations (for example, Godfrey, 1958*b*; Hoar, 1951; Neave, 1953; Neave, 1958; Wickett, 1958; cf. Rostlund, 1952, pp. 15ff.) indicate that among the conditions responsible for the year-to-year fluctuations in the size of Pacific salmon populations are such environmental factors as variable water levels and temperatures in the spawning streams, occasional extreme floods, variable temperatures and salinity in the ocean, and the variable freshwater runoffs and the action of tides, currents, winds, and deep-water upwelling in the estuarine and inshore waters that are the habitat of the young salmon for weeks or perhaps months before they reach the open seas. These kinds of variable environmental conditions are likely to have influenced the size of salmon populations in previous centuries as well as in the present one and may therefore be cited as another indication that the production of food by particular Kwakiutl communities may have been far less in excess of subsistence requirements in some years than in others during the period when the Kwakiutl still had their old culture. Also noteworthy are ethnological references to hungry Kwakiutl tribes (Boas, 1921, pp. 196 and 198) and a reference in Kwakiutl mythology to a "starving people [who] pay for food with dressed elkskins, slaves, canoes and even their daughters" (Boas, 1935, p. 67).

The last reference is of interest not only as an indication of important temporal variations in food production. It suggests also that the Kwakiutl, like the Coast Salish, had mechanisms for converting wealth into food and food into wealth. The existence of such mechanisms is suggested also by references in Kwakiutl mythology to people who "go out in canoes and buy food from another tribe," "a man [who] catches many herrings at his beach ... [and] sells them for slaves," and a "chief [who] goes out and buys many cherries from the neighboring tribe" (Boas, 1935, p. 67). In historical times, food-for-wealth exchanges are well documented. For example, Boas (1897, p. 342) mentions the "selling" of blankets for food among the 19th century Kwakiutl. Food could also be sold for money in the historical period, and the money could in turn be used either for the acquisition of prestige goods or else for getting food at some later time (Codere, 1950, pp. 33, 35, and *passim;* cf. Ford, 1941, pp. 169ff.). No doubt the Kwakiutl, like the Coast Salish, had some restrictions upon making food-for-wealth exchanges, but what the restrictions were is not clear (see the discussion in Mauss, 1954, pp. 41 to 42).

The Kwakiutl system was, of course, not exactly the same as the Coast Salish one. Thus it may be noted that among the Kwakiutl there does not appear to have been the Coast Salish requirement that intercommunity food-for-wealth exchanges be between affinal relatives. Nevertheless, Piddocke is able to propose a reinterpretation of Kwakiutl

economics similar to Suttles' reinterpretation of Coast Salish economics. Among the Kwakiutl, as among the Coast Salish, relatively perishable subsistence goods could be "converted" into more durable wealth. The wealth, if not reconverted at a later time into food, could be converted at potlatches into prestige. Prestige too might be reconverted. For example, if group A gave to group B an amount of wealth exceeding in value that which B subsequently requited, then B might be giving up some of its prestige to A in return for the "excess" amount of wealth that A had given.

The famous Kwakiutl practice of not distributing but rather destroying such goods as blankets and coppers in order to gain prestige may also be regarded as a mechanism reducing inequalities in the distribution of goods among communities. It is possible, however, that the mechanism was in operation but rarely, if at all, in precontact times and that it became important among the Kwakiutl only in the later historical period when, because of such commercial activities as fur trading, fishing, and logging, the inequalities in the distribution of goods developed more quickly and more markedly than before. In Kwakiutl mythology, which presumably reflects the older culture, the destruction of property, whether in potlatches or under other circumstances, is unimportant. Boas' volume *Kwakiutl Culture as Reflected in Mythology* has only the following to say about it: "In myths the destruction of property occurs only in connection with the cannibal ceremony when the cannibal devours his own slaves or is given slaves to eat. Canoe breaking during a potlatch occurs in a tale in which the person who breaks canoes owned by others makes them whole again by his magical powers ....A man pushes a copper under a mountain during a feast ... "(Boas, 1935, p. 69).

More significant perhaps is the fact that the destruction of property does not seem to have been mentioned in the accounts that we have of Kwakiutl potlatches even in the 1870s and 1880s (Codere, 1950, p. 81ff.). Did the destruction of property become a prominent feature of Kwakiutl potlatching only in the last years of the 19th century? Perhaps so.

We may note that not only the greater destructiveness but also the apparently greater frequency of Kwakiutl potlatches (Codere, 1950, pp. 97) may have been a late 19th century adjustment to the influx of new wealth. Because the inequalities in the distribution of wealth developed more quickly and more markedly than before, the mechanisms reducing the inequalities had to be in operation more often if the old system was to be maintained.

Concluding Remarks

Much research on Northwest Coast economies still needs to be done. I have the hope, however, that focussing attention right now upon possi-

ble interpretations, such as those that I have been proposing, will be a means for stimulating and guiding further investigations.

It may very well be asked why the Northwest Coast Indians *should* have had the kind of economic systems that I have been suggesting they *may* have had. In order to answer this, it would be necessary to try to indicate, among other things, the advantages that having these economic systems would have given to the people and the adversities from which it would have protected them. A hypothesis to which I have already alluded is suggested by the interpretations of Suttles and Piddocke: namely, that as the effectiveness of food production was varying from time to time and from place to place, there were movements and countermovements of food, wealth, and prestige from person to person and from group to group in such a way as to minimize the adverse effects (starvation, hostilities against neighbors, and death) of any local and temporary lack of success in food production. In more general terms, the hypothesis is that the self-regulating economic systems served to distribute goods in a way that contributed to the survival and well-being of the people.

In considering a hypothesis of this kind, we are returning to the issues raised earlier about the adaptiveness or nonadaptiveness of Northwest Coast economic systems. In the absence of more complete data on the movements of goods, especially on the directions, timing, frequencies, and magnitude of the movements, our hypothesis cannot of course be regarded as proved. Nevertheless the mere fact that it seems both plausible and consistent with the extant evidence suffices to show that it is premature and unwarranted to conclude that the potlatching and associated customs of the Northwest Coast Indians were topsy-turvy, nonadaptive, nonfunctional, absurdly wasteful, or little related to problems of livelihood.

References

BENEDICT, R. 1934, Patterns of Culture. Houghton Mifflin. Boston, Mass.

BOAS, F. 1897. The social organization and the secret societies of the Kwakiutl Indians. Report of the U. S. National Museum ... for the Year Ending June 30, 1895. : 311-738. Government Printing Office. Washington, D. C.

BOAS, F. 1921. Ethnology of the Kwakiutl, based on data collected by George Hunt. Thirty-fifth Annual Report of the Bureau of American Ethnology ... 1913-1914. : 43-1481. Government Printing Office. Washington, D. C.

BOAS, F. 1935. Kwakiutl Culture as Reflected in Mythology. Memoirs of the American Folk-lore Society. 28. American Folk-lore Society, New York, N.Y.

COBB, J. N. 1921. Pacific salmon fisheries. Appendix I to the Report of the U. S. Commissioner of Fisheries for 1921 (Bureau of Fisheries Document No. 902), 3rd ed. Government Printing Office. Washington, D. C.

CODERE, H. 1950. Fighting with property. A study of Kwakiutl potlatching and warfare 1792-1930. Am. Ethnol. Soc. Monogr. No. 18. J. J. Augustin. New York, N. Y.

DICE, L. R. 1955. Man's Nature and Nature's Man. The Ecology of Human Communities. Univ. Mich. Press. Ann Arbor, Mich.

FORD, C. S. 1941. Smoke from their Fires. The Life of a Kwakiutl Chief. Yale Univ. Press. New Haven, Conn.

GODFREY, H. 1958a. A comparison of sockeye salmon catches at Rivers Inlet and Skeena River, B. C., with particular reference to age at maturity. Jl. of the Fisheries Research Board of Canada. 15: 331-354. Ottawa, Canada.

GODFREY, H. 1958b. Comparisons of the index of return for several stocks of British Columbia salmon to study variations in survival. J. Fisheries Research Board Canada. 15: 891-908.

GOLDMAN, I. 1937. The Kwakiutl Indians of Vancouver Island. *In* Cooperation and Competition among Primitive Peoples. : 180-209. M. Mead, Ed. McGraw-Hill. New York, N. Y.

HERSKOVITS, M. J. 1952. Economic Anthropology. A Study in Comparative Economics. Knopf. New York, N. Y.

HOAR, W. S. 1951. The chum and pink salmon fisheries of British Columbia 1917-1947. Bulletin of the Fisheries Research Board of Canada. 90. Fisheries Research Board of Canada. Ottawa, Canada.

LINTON, R. 1955. The Tree of Culture. Knopf. New York, N. Y.

MAUSS, M. 1954. The Gift. Forms and Functions of Exchange in Archaic Societies. Trans. by Ian Cunnison. Free Press. Glencoe, Ill.

NEAVE, F. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fisheries Research Board Canada. 9: 450-491.

NEAVE, F. 1958. Stream ecology and production of anadromous fish. *In* The Investigation of Fish-Power Problems: H. R. MacMillan Lectures in Fisheries. : 43-48. P. A. Larkin, Ed. Univ. British Columbia. Vancouver, B. C.

OUTRAM, D. N. 1956. Amount of herring spawn deposited in British Columbia coastal waters in 1956. Circular No. 42 of the Pacific Biological Station, Fisheries Research Board of Canada. Nanaimo, B. C.

OUTRAM, D. N. 1957. Extent of herring spawning in British Columbia in 1957. Circular No. 46 of the Pacific Biological Station, Fisheries Research Board of Canada. Nanaimo, B. C.

OUTRAM, D. N. 1958. The 1958 herring spawn deposition in British Columbia coastal waters. Circular No. 50 of the Pacific Biological Station, Fisheries Research Board of Canada. Nanaimo, B. C.

PIDDOCKE, S. 1960. The potlatch system of the Southern Kwakiutl. Unpublished manuscript.

ROSTLUND, E. 1952. Freshwater fish and fishing in native North America. Univ. Calif. Publ. Geog. 9.

SUTTLES, W. 1960. Affinal ties, subsistence, and prestige among the Coast Salish. Am. Anthropologist. 62: 296-305.

WHITE, L. A. 1959. The Evolution of Culture. The Development of Civilization to the Fall of Rome. McGraw-Hill. New York, N. Y.

WICKETT, W. P. 1958. Review of certain environmental factors affecting the production of pink and chum salmon. J. Fisheries Research Board Canada. 15: 1103-1126.

DIVISION OF ENGINEERING

FUTURE SOURCES OF DRINKING WATER*

John W. Colton

Scientific Design Co., Inc., New York, N. Y.

Exhaustion of natural supplies of potable water is generally recognized as a serious problem, acute today in some areas, but merely impending in the better-favored areas of the world. Poverty and soil erosion in the eastern Mediterranean region are intimately associated with the water shortage there.[1] Other areas, such as Australia, the southwestern United States, and northwestern Africa, could greatly accelerate their rate of development if the water supply were more adequate. Increasing population and increasing per capita demands for water will eventually bring even the better-favored areas to the point of exhaustion of natural sources.

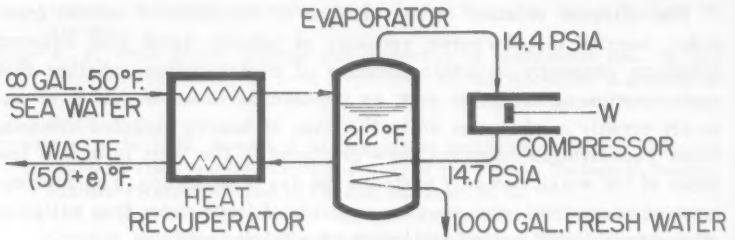
The ultimate solution to the problem of depletion of natural fresh water sources is, of course, recovery of potable water from aqueous solutions presently unusable because of contamination, whether that contamination be inorganic salt, as in the case of ocean water, or primarily organic in character as in the case of heavily polluted streams. Water conservation measures, now practiced to the limit in only a few areas of the world, can only postpone the day of reckoning. The development of economical processes for recovery of fresh water from saline or otherwise polluted waters will become a vital necessity.

In 1952, the United States government recognized its responsibilities in this field by establishing a bureau in the Department of the Interior known as the Office of Saline Water (OSW). The purpose of this bureau was to set up and co-ordinate research and development in the field of recovery of potable and irrigation water from saline waters. Because of budget limitations the OSW called in industrial firms and outside research laboratories to carry out the program. To date there are contracts for research in this field to 46 individual firms working on many different approaches to the problem. Undoubtedly, with a stimulus thus provided, at least one or, more likely, several competitive economic processes will be developed.

The OSW program as authorized by 1958 legislation will culminate in a series of five large-scale demonstration plants, each to check out a different, promising new conversion process. Four such plants are under construction with capacities of 250,000 gal./day to 1 million gal./day. The fifth demonstration plant, using an unspecified freezing process, has recently had an architect-engineers contract awarded.

* This paper illustrated with slides, was presented at a meeting of the Division of Engineering on February 8, 1961.

The most important and promising processes fall into three categories: evaporation, freezing, and membrane. Either a change of physical state of the water is required, or else the passage of either the salt or the water through a selective membrane is necessary to separate the water from the salt. Furthermore, it can be stated categorically that no two processes operating in a thermodynamically perfect manner, that is, reversibly and isothermally, can have a different theoretical energy requirement. Otherwise a perpetual motion machine could be established. The minimum energy of separation of pure water from ocean water has been calculated by various authors as lying between 2.6 and 3 kwh./1000 gal.[2,3] This minimum theoretical energy requires an infinite amount of sea water from which to obtain any finite amount of fresh water. It is an impractical but theoretically significant limitation. FIGURES 1 to 4, show the theoretical minimum work of separation for several different mechanisms. In FIGURE 1 – vapor recompression – the vapors from sea water boiling at 212° F. are compressed from their boiling point



$$\text{ISOTHERMAL } W = nRT \ln \frac{P_2}{P_1}$$

$$W = \frac{8340 \cdot 1546 \cdot 672}{18 \cdot 2.66 \cdot 10^6} \ln \frac{14.7}{14.4} = 3.58 \text{ KWH/M GAL.}$$

$$\text{ADIABATIC } W = nRT \frac{k}{k-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} - 1\right]$$

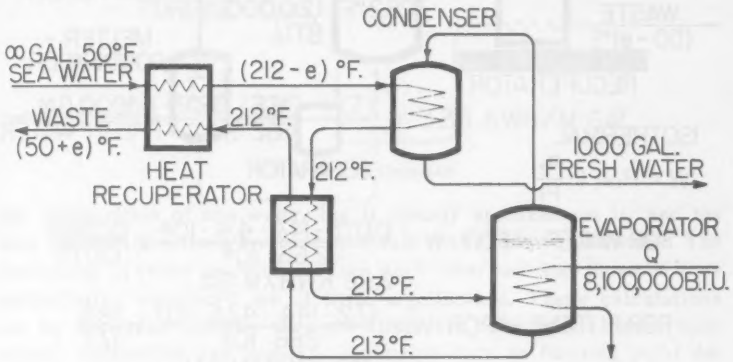
$$W = \frac{8340 \cdot 1546 \cdot 672 \cdot 1.32}{18 \cdot 2.66 \cdot 10^6 \cdot 0.32}\left[\left(\frac{14.7}{14.4}\right)^{\frac{0.32}{1.32}} - 1\right] = 3.76 \text{ KWH/M GAL.}$$

FIGURE 1. Vapor recompression

pressure, approximately 14.4 psia, to 14.7 psia, and the latent heat of condensation is transferred through a coil to supply the latent heat of boiling. Isothermally the work of compression is about 3.6 kwh./1000 gal., but the adiabatic work of compression is slightly higher, approximately 3.8 kwh./1000 gal.

In single-stage evaporation (FIGURE 2), a simple Carnot cycle is used to estimate the work value of the heat employed to boil water. This heat, 8,100,000 B.T.U./1000 gal., is introduced at a temperature of 673°

R. (213° F.) and reappears in a differential temperature rise of the rejected sea water. If this heat were used to drive a turbine operating between these two temperatures, it could generate 575 kwh. of power. Obviously, single-stage evaporation is a thermodynamically extravagant method of obtaining fresh water from sea water. As a matter of practice, almost all evaporation processes employ multiple stages, utilizing the latent heat of condensation of the water from one stage to boil sea water at a lower temperature and pressure. In this particular case with water boiling at atmospheric pressure, the condenser may be considered to be the heat sink, in which case the Carnot cycle dictates that the work value of the heat introduced is approximately 3.5 kwh/1000 gal.



$$W = Q\left(\frac{T_1 - T_2}{T_1}\right) = \frac{8.1 \cdot 10^6}{3413}\left(\frac{673 - 510}{673}\right) = 575 \text{ KWH/M GAL.}$$

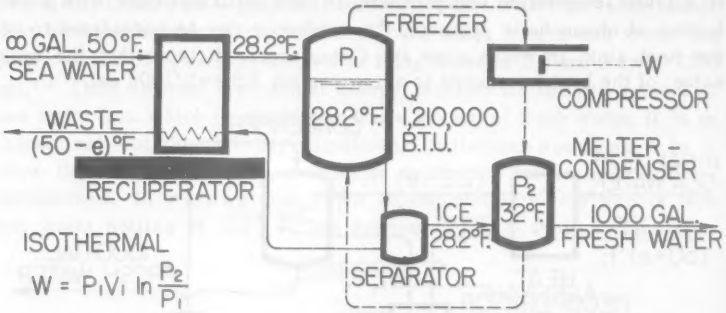
160 STAGES W = 3.5 KWH/M GAL.

FIGURE 2. Single-stage evaporation

Freezing processes of interest require evaporation of a refrigerant in direct contact with the contaminated solution, followed by compression of the refrigerant and its condensation in direct contact with the melting ice. No heat-transfer surface is used. The refrigerant may be an added component, or water vapor itself.

For the case of freezing (FIGURE 3), a different form of the perfect gas laws was used to estimate the work requirement for producing 1,000 gal. of fresh water from sea water. The reason for using the alternate form is to point out the extremely low pressure and large volumes required for water vapor compression. In FIGURE 3, it may be noted that every 1,000 gal. of water would require 4,400,000 cu. feet of vapor to be compressed in order to provide the latent heat of freezing the ice in this process. Furthermore, the very low absolute pressures of the process lie in a range in which compressors are extremely inefficient. It

seems more logical to add a refrigerant of higher vapor pressure than water; preferably this refrigerant of higher vapor pressure than water; preferably this refrigerant should be immiscible with water, and cheap. Butene-1 fulfills all requirements. It forms no hydrocarbon hydrate (hydrate formation with certain other refrigerants adds an economic penalty to the process). Furthermore, in the freezing cycle, the vapor pressure of butene-1 is never below atmospheric nor very high above it.



$$\text{FOR WATER VAPOR } W = \frac{0.075 \cdot 144 \cdot 4.4 \cdot 10^6}{2.66 \cdot 10^6} \ln \frac{0.0885}{0.075}$$

$$= 2.96 \text{ KWH/M GAL.}$$

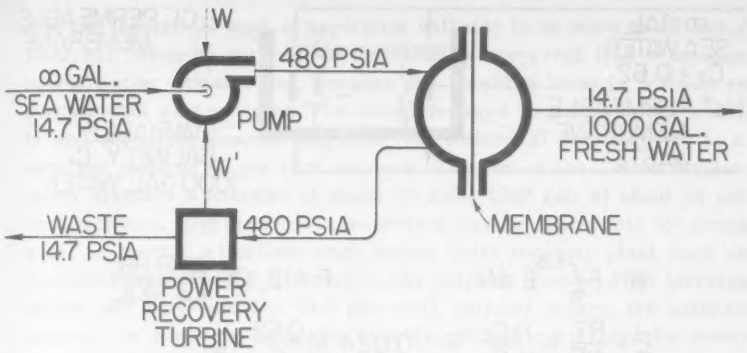
$$\text{FOR BUTENE VAPOR } W = \frac{17.2 \cdot 144 \cdot 42.6 \cdot 10^3}{2.66 \cdot 10^6} \ln \frac{18.6}{17.2}$$

$$= 3.05 \text{ KWH/M GAL.}$$

FIGURE 3. Freezing

Reverse osmosis, shown in FIGURE 4, depends upon the ability of certain semipermeable membranes to pass water but not its dissolved electrolytes. The pressures on the two sides of the membrane are quite different however. For some enigmatic reason the osmotic pressure can be calculated by using the gas law constant, $PV = nRT$, wherein the pressure of the feed solution can be calculated from the number of mols of the electrolyte dissolved, the absolute temperature T, the gas constant R, and the volume of solution that would be equivalent to the volume of that number of mols of electrolyte if the electrolyte were a perfect gas. In this reverse osmosis example, the net work required, 3.4 kwh./1000 gal., is that necessary to pump up the product water from atmospheric pressure to 480 psia. Although a large amount of sea water must also be pumped up to the higher pressure, it is assumed that this sea water can be released through a perfect power recovery turbine, thus requiring no net work for the unused sea water.

All of the above four examples have been calculated using a reversible perfect thermodynamic process to produce absolutely pure water from a solution containing 3.5 per cent NaCl. This solution, of course, is not



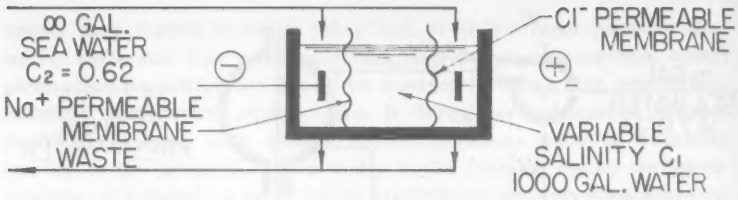
$$W = V(P_2 - P_1)$$

$$W = \frac{134 \cdot 144 \cdot (480 - 14.7)}{2.66 \cdot 10^6} = 3.38 \text{ KWH/M GAL.}$$

FIGURE 4. Osmosis

the composition of sea water, but it closely approximates it, and the data on NaCl solutions are more abundant than those on sea water. The deviations of these calculations from each other and from those of more authoritative sources[2,3] are of little significance. These calculations are by no means precise; they are slide rule calculations based upon readily accessible and possibly inaccurate data on freezing point depression, boiling point elevation, vapor pressure lowering, and osmotic pressure data, and the assumed processes operate in different physical environments.

One more example shown in FIGURE 5 shows the limiting thermodynamic work involved in electrodialysis. Although there is an electrochemical reaction occurring at the electrodes to produce hydrogen, caustic, and chlorine, one must neglect the electrical potential of that reaction in computing the minimum work involved to produce fresh water from ocean water. Consider an infinite number of compartments separated by ion-selective membranes. Odd-numbered membranes are permeable to positive ions, and even-numbered membranes to negative ions. The compartments in the center of the diagram (FIGURE 5) represent all of the compartments containing water that is to be freshened. The end compartments of the diagram represent all the alternate cells of a real process that contain water of ocean water salinity. This model is now a concentration cell in which salt is being lifted from a solution of low concentration to one of high concentration. This requires an EMF across each membrane changing with time from zero to about one tenth of a volt in a batch operation. The theoretical minimum work in this example turns out to be 2.8 kwh./1000 gal. This is lower than the other examples



$$W = F\int_0^{5.15} E\, dN \qquad F = 12{,}100\ \frac{\text{AMP. HR.}}{\text{LB. MOL.}}$$

$$E = \frac{RT}{NF} \ln \frac{\gamma_2 C_2}{\gamma_1 C_1} \cong -0.024 \ln \frac{0.62}{C_1} \times 2$$

$$dN = -8.34\, dC_1$$

$$W = 4.84\int_{0.0085}^{0.62} \ln \frac{C_1}{0.62}\, dC_1 = 2.78 \text{ KWH/M GAL.}$$

FIGURE 5. Electrodialysis

given above for two reasons: (1) This is a differential batch operation instead of a steady-state, single-stage operation; (2) the product water is not absolutely pure but contains 500 ppm NaCl.

In summary, we can conclude that all saline water conversion processes require about the same minimum thermodynamic energy.

The theoretical power requirements of a finite conversion process will vary with the concentration of the solution from which water is being extracted. FIGURE 6, copied from a paper by E. R. Gilliland,[2] shows

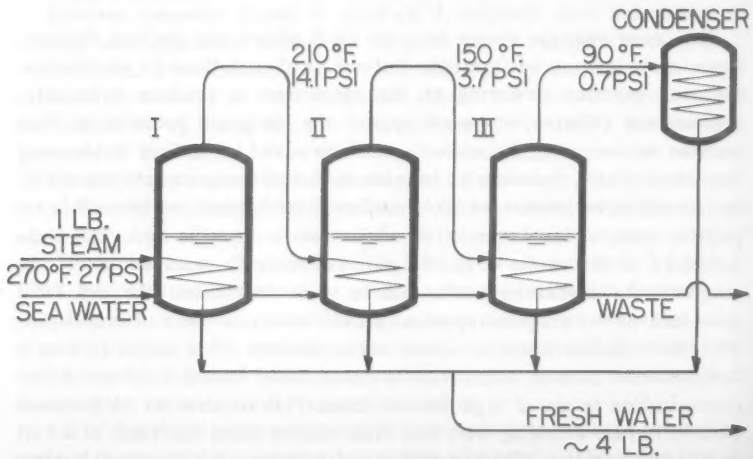


FIGURE 6. Multiple effect evaporation

that the theoretical work of separation will rise to as much as 12 kwh./1000 gal. when 80 per cent of the water is recovered from a solution approximating ocean water, because the resulting brine is 5 times as concentrated as sea water. The energy required to pump the sea water in and out of the process drops off from infinity at zero recovery to a very low level at 40 per cent recovery. The sum of the 2 work requirements displays a minimum of about 4½ kwh./1000 gal. at about 30 per cent recovery. Higher or lower recoveries may be appropriate for ocean water in special situations; each saline water recovery plant must be evaluated economically to determine the optimum recovery. For brackish waters and very pure (ca. 99.9 per cent) polluted waters, the optimum recovery is likely to be higher than the 30 per cent noted for ocean water.

I shall now discuss the relative merits of the more important processes for the conversion of contaminated waters to fresh water. Each of the three major categories has advantages and disadvantages that make it more or less attractive for given geographical and economic situations.

Multiple-effect evaporation is by far the most commercially used technique: it is used today on all large ocean-going ships and in at least ten large shore-based installations. It has the advantage of simplicity, except in its more sophisticated versions, and it can be operated at reasonable cost even in small installations. It has the disadvantage of high costs, ranging in the neighborhood of $1.00 to $2.00 per thousand gallons fresh water, and it suffers from the physical handicaps of corrosion accelerated by high temperature and scale formation.

Electrodialysis, one of the two membrane processes under serious consideration, is the second most commercially used process. One company alone has 34 installations in service today and 19 under construction. This is no mean achievement, since the technology is quite complex. The process suffers from the limitation that it cannot be used on nonelectrolytic solutions, nor on highly concentrated saline solutions such as ocean water. The reason for the former limitation is readily apparent. The reason for the latter is that the membranes lose efficiency when operating on concentrated solutions. For recovery of potable water from brackish waters, however, electrodialysis is probably an attractive method. Costs vary widely with the degree of salinity of the feed water.

Reverse osmosis is not practiced commercially. Development of membranes capable of withstanding high pressures and giving high throughputs has proved a problem. Reverse osmosis offers promise, however, in the purification of polluted waters of low initial salinity.

Freezing processes in general offer the greatest promise for lowest-cost water supplies. A freezing process is readily adapted to use any feedstock: concentrated or dilute electrolytic solutions, or nonelectrolytic solutions. It is most feasible for large volume supplies of water since it

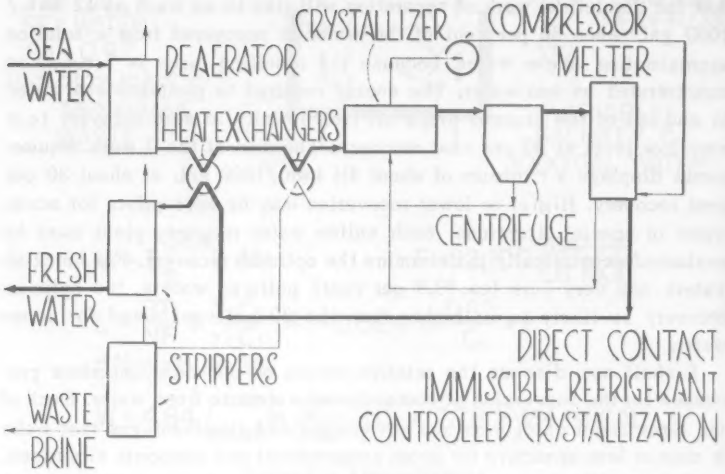


FIGURE 7. Direct contact immiscible refrigerant-controlled crystallization

depends upon careful attention to thermodynamic efficiency for its economy of operation. Refinements, such as multistage conversion, multistage refrigerant recovery, and highly efficient compression cycles are feasible only in large capacity plants. However, it is inherently the lowest-cost method of converting ocean water to fresh water. Operating and maintenance costs run in the neighborhood of 30 cents per thousand gallons with capital costs in the neighborhood of 60 to 80 cents per gallon per day.

In this connection it might be interesting to compare the cost of water produced by freezing with the cost of water by an apparently expensive natural recovery scheme presently being considered. The principal and most controversial feature of the California Water Plan is a proposal to convey water from the Feather River in northern California 750 miles to Los Angeles over mountains about 4,000 feet high. The capital expenditure for this operation of the California Water Plan alone is estimated at $3,000,000,000,[4] about $6.00 per gallon per day of capacity. Operating and maintenance costs have been estimated between 6.1 and 20 cents per thousand gallons delivered. This has been commented on as one of the more spectacular and costly projects ever seriously considered for the recovery and transportation of naturally occurring potable water supplies.[4] Let us compare the economics of this project with the economics of a typical ocean-water conversion plant, using the freezing process.

To make this comparison as simple as possible all costs will be divided into two categories: capital-associated costs on the one hand,

and operating and maintenance on the other. Capital costs for large water supplies are usually funded by a bond issue with a sinking fund attached. This means a total dollar investment at any given date that is a strong function of the interest rate. It is either the present value of an annuity or at some future date the total number of dollars paid into the sinking fund at compount interest. Changes in the value of money that operate in the modern socioeconomic equilibrium to offset the influence of interest are neglected in this comparison. Without debating the merits of what is the preferred interest rate for such projects, an arbitrary 5 per cent per annum interest is used in this comparison. Tax-free bonds could be floated at lower interest rates, especially if the state treasury backs them up. This is, in the opinion of some writers, a direct subsidy, since the California Water Plan cannot possibly pay back its costs of construction at the present delivered water prices prevailing in Los Angeles.[4] Interest rates higher than 5 per cent prevail in the general business community, especially where, as in this case, the interest rate is really a reflection of return on equity capital.

TABLE 1

OFFICE OF SALINE WATER DEMONSTRATION PLANTS

Location	Process	Designers
Freeport, Texas 1 MM. gal./day	Multiple-effect evaporation Long-tube vertical	Badger & Assoc.
Point Loma, San Diego, Calif. 1 MM. gal./day	Multistage flash	Fluor
Roswell, N. Mex. 250 M. gal./day	Vapor recompression	Catalytic
Webster, South Dakota 250 M. gal./day	Electrodialysis	Asahi
Wrightsville Beach, N. C. 250 to 300 M. gal./day	Freezing	Lummus

Using the typical parameters and costs spelled out in TABLE 2, we see that in 1981 the capital expenditures for the saline water conversion plant would be approximately one eighth that of the comparable natural water impoundment and transportation system. The total delivered water for the conversion plant throughout its lifetime would be about one third that of the dam and aqueduct due to the difference in projected lifetimes of the two systems. For every thousand gallons of water delivered, the capital costs, as defined above, in 1981 will be 16.7 cents per thousand gallons for the ocean water conversion plant and 45.7 cents

TABLE 2

COMPARISON OF COSTS OF FRESH WATER
Capacity 100,000 M. gal./day

	Sea water conversion	Dam & aqueduct
Plant capital	$\$80 \times 10^6$	$\$600 \times 10^6$
Working life*	40 years	100 years
Bond issue at 5%	20 years	40 years
Total capital costs at 1981 date	$\$213 \times 10^6$	$\$1585 \times 10^6$
Total delivered water*	1.28×10^9 M. gal.	3.47×10^9 M. gal.
Unit costs:		
Capital	16.7¢/M. gal.	45.7¢/M. gal.
operating & maint.	30.0¢/M. gal.	5.0¢/M. gal.
Total unit costs	46.7¢/M. gal.	50.7¢/M. gal.

*Schedule assumes five years of unused capacity during initial operating period.

per thousand gallons for the natural water supply. When operating and maintenance costs are added to this, the total unit costs are about 10 per cent less for the ocean water conversion plant.

It should be emphasized that the comparison in TABLE 2 is between the best projected figures for ocean water conversion (that is, freezing) and a very costly project conceived for natural water recovery. In almost all other instances where natural waters are available at more reasonable distances than in California, natural water supplies are still to be preferred economically.

Most of the attention has been focused in recent years on the recovery of water from saline solutions such as those of the ocean or brackish supplies. There is a much more economical source of water available for use in conversion plants at any large metropolitan area, namely recycled sewage effluent. Squeamishness on this subject should be avoided. Mankind has been drinking purified or diluted sewage effluent for generations. Usually purification is accomplished by soil filtration, and dilution occurs when cities draw their water supplies from polluted rivers. During the drought of 1956-1957 one town in Kansas subsisted entirely on its own sewage.[5] Total recycle of this type is to be avoided, however, unless means of water purification – as opposed to water treatment – are employed. Conventional water and sewage treatments are not adequate for a total recycle over an extended period of time. By employing a water conversion process one can eliminate the accumulated salts and organic contaminants that conventional treatments do not remove. Since the contamination load of sewage will run about

one tenth of 1 per cent, as opposed to the 3.5 per cent contamination load of sea water, the costs of obtaining pure water from sewage effluent are substantially less than those from sea water. Preliminary projected estimates for a large-capacity freezing plant operating on sewage effluent show an operating and maintenance cost of about 20 cents per thousand gallons and a capital investment of about 50 cents per gallon per day. The operating and maintenance costs are substantially higher, but the capital costs are in the same order of magnitude as conventional water-treatment facilities. The recovered water from a conversion process should be much purer than the public water supply of any city in the world today, although this point has not yet been confirmed by actual experiments.

The next few years will mark another milestone in the path of human progress. Mankind can expect to be manufacturing pure water for its needs instead of depending upon natural sources exclusively just as, years ago, mankind began to cultivate food plants and domesticate cattle in place of depending upon scavenging and hunting for food. For another basic human need, men will learn to accelerate and guide nature's processes for the greater convenience of their own lives.

References

1. GLESINGER, E. 1960. The Mediterranean Project — Scientific American, 203: 86-103.
2. GILLILAND, E. R. 1955. Fresh water for the future. Ind. Eng. Chem. 47(12): 2410-2422.
3. DODGE, B. F. & A. M. ESHAVA. 1960. Thermodynamics of some desalting processes. Advances in Chem. Series, No. 27, Saline Water Conversion.
4. HIRSHLEIFER, DE HAVEN & MILLIMAN. 1960. Water Supply — Economics, Technology & Policy — Rand Corporation Study. Univ. Chicago Press. Chicago, Ill.
5. METZLER, D. F., R. L. CULP, H. A. STOLTENBERG, R. L. WOODWARD, G. WALTON, S. CHANGE, N. A. CLARKE, C. M. PALMER & F. M. MIDDLETON. 1958. Emergency use of reclaimed water for potable supply at Chanute, Kansas. J. Am. Water Works Assoc. 50: 1021-1060.

CONFERENCES HELD

SECTION OF BIOLOGICAL AND MEDICAL SCIENCES

SOME BIOLOGICAL ASPECTS OF SCHIZOPHRENIC BEHAVIOR

Thursday, April 6
Friday, April 7, and
Saturday, April 8, 1961

Conference Chairman:
D. V. Siva Sankar
Creedmoor State Hospital, Jamaica, N. Y.

THURSDAY, APRIL 6, 1961

A. STUDIES OF EXPERIMENTAL PSYCHOSES AND NEUROHORMONES

Session Chairman: Bernard B. Brodie
National Institutes of Health,
Bethesda, Md.

9:00 A.M. –
Greetings from the Academy - Preston L. Perlman, Vice-Chairman, Section of Biological and Medical Sciences, The New York Academy of Sciences, New York, N. Y.; Schering Corporation, Bloomfield, N. J.

Introductory Remarks - Paul H. Hoch, Department of Mental Hygiene, State of New York, Albany, N. Y.

"New Developments in Metabolism of Mescaline and Related Amines" - Arnold J. Friedhoff and M. Goldstein, Department of Psychiatry and Neurology, New York University College of Medicine, New York, N.Y.

"Studies on Mescaline XIII - The Effect of Prior Administration of Various Psychotropic Drugs on Different Biochemical Parameters" - Herman C. B. Denber, David M. Teller, Paul Rajotte, and Dorothy Kauffman, Manhattan State Hospital, New York, N. Y.

"Methylation and Demethylation in Relation to the *In Vitro* Metabolism of Mescaline" - R. Daly and J. Axelrod, National Institutes of Health, Bethesda, Md.

"Biochemical Aspects of Time in Relation to (Model) Psychoses" - Roland Fischer, Columbus Psychiatric Institute and Hospital, Columbus, Ohio.

"Adrenal Cortical and Corticotropic Hormone Changes Under Experimentally Induced Anxiety States" - Harold Persky, Institute of Psychiatric Research, Indiana University Medical Center, Indianapolis, Ind.

"The Psychosis of Sleep Deprivation" - Louis J. West, Department of Psychiatry, Neurology and Behavioral Sciences, University of Oklahoma Medical Center, Oklahoma City, Okla.

"Biochemical, Autonomic, and Psychological Responses to Sleep Deprivation: Implications for the Theory of Schizophrenia" - Elliot D. Luby, Lafayette Clinic, Detroit, Mich.

"Drug-Induced Psychoses and Schizophrenic Reactions: A Critical Comparison" - Leo E. Hollister, Veterans Administration Hospital, Palo Alto, Calif.

Session Chairman: Julius Axelrod
National Institutes of Health
Bethesda, Md.

2:00 P.M. –

"Effect of LSD, BOL, and Chlorpromazine of 'Neurohormone' Metabolism" - D. V. Siva Sankar, Edward Phipps, Eleanor Gold, and D. Barbara Sankar, Children's Unit, Creedmoor State Hospital, Jamaica, N. Y.

"LSD-25 and the Status and Level of Brain Serotonin" - Daniel X. Freedman and Nicholas J. Giarman, Department of Pharmacology, Yale University School of Medicine, New Haven, Conn.

"Exploration of Central Nervous System Serotonin in Humans" - D. W. Woolley, Rockefeller Institute, New York, N. Y.

"On Current Status of Serotonin as Brain Neurohormone and In Action of Reserpinelike Drugs" - E. Costa, E. Cuenca, G. L. Gessa, and R. Kuntzman, Laboratory of Chemical Pharmacology, National Heart Institute, Bethesda, Md.

"6-Hydroxylation of Tryptamine Derivatives: A Way of Producing Psychoactive Metabolites" - Stephen Szara, Saint Elizabeth's Hospital, Washington, D. C.

"Effect of 4-Hydroxyindoles on the Metabolism of 5-Hydroxytryptamine" - Mirriam Wiseman-Distler and Theodore L. Sourkes, Allan Memorial Institute, Montreal, P. Q., Canada.

"Metabolism of Dihydroxyphenylalanine in the Presence of Psychoactive Drugs" - Dale Friend, Peter Bent Brigham Hospital, Boston, Mass.

FRIDAY, APRIL 7, 1961

B. STUDIES ON PSYCHOPHARMACOLOGICAL DRUG ACTIONS

Session Chairman: Dale Friend
Peter Bent Brigham Hospital
Boston, Mass.

9:00 A.M.—

"Schizophrenic Behavior and Aspects of Psychopharmacology" - George G. Haydu, Creedmoor Institute for Psychobiologic Studies, New York, N.Y.

"Metabolic Studies on Psychoactive Drugs" - C. Jelleff Carr, Psychopharmacology Service Center, National Institutes of Health, Bethesda, Md.

"Metabolic Effects of Psychoactive Drugs" - P. Greengard and Gertrude P. Ouinn, Geigy Research Laboratories, Ardsley, N. Y.

"The Effect of CNS Drugs on the Incorporation of Radioactive Carbon into Brain Adenosine Triphosphate" - Harry G. Albaum, Brooklyn College, Brooklyn, N. Y.

"Effects of Drugs on Psychological Development" - John L. Fuller, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

"Catecholamines and Narcotic Drugs" - L. E. Gunne, Karolinska Institute, Stockholm, Sweden.

"Synaptic and Behavioral Correlates of Psychotherapeutic and Related Drug Actions" - Amedeo S. Marrazzi, Veterans Administration Research Laboratories in Neuropsychiatry, Pittsburgh, Pa.

"Behavioral and EEG Effects of Intraventricular Injection of Bulbocapnine and Other Substances in Freely Moving Animals" - John A. Wada, Faculty of Medicine, University of British Columbia, Vancouver, B.C., Canada.

Session Chairman: Amedeo S. Marrazzi
Veterans Administration Research Laboratories in Neuropsychiatry
Pittsburgh, Pa.

2:00 P.M.—

"Cholinergic Blockade as an Approach to the Development of New Psychotropic Agents" - John H. Biel, Patrick A. Nuhfer, Wallace K. Hoya, and Helen A. Leiser, Lakeside Laboratories, Inc., Milwaukee, Wis., and Leo G. Abood, Department of Psychiatry, University of Illinois School of Medicine, Chicago, Ill.

"Possible Modes of Action of Psychotherapeutic Agents in the Treatment of Mental Disturbances". Milton Kletzkin, Wallace Laboratories, Cranbury, N. J.

"On Mechanism of Antidepressant Actions of Imipramine-like Drugs that Act Only in Depressed States" - F. Sulser, National Institutes of Health, Bethesda, Md.

"EEG and Biochemical Findings with Monoamine Oxidase Inhibitors" - William H. Funderburk, Kenneth F. Finger, and Anna Drakontides, Research Laboratories, Chas. Pfizer & Co., Inc., Groton, Conn.

"Effects of Chlordiazepoxide (Librium) and Other Psychotropic Agents on the Limbic System of the Brain" - William Schallek, Hoffmann-La Roche Inc., Nutley, N. J.

"Drug Effects on the Behavior of Animals" - Leonard Cook, Smith, Kline and French Laboratories, Philadelphia, Pa.

"Some Central Nervous System Drugs Designed from Metabolic Considerations" - Rex Pinson, Jr., Barry M. Bloom, and C. J. Buck, Research Laboratories, Chas. Pfizer & Co., Inc., Groton, Conn.

SATURDAY, APRIL 8, 1961

C. STUDIES ON SCHIZOPHRENIA AND BEHAVIOR

Session Chairman: Leo E. Hollister
Veterans Administration Hospital,
Palo Alto, Calif.

9:00 A.M. –
"Molecular Biology in Schizophrenia" - R. G. Grenell, Psychiatric Institute, University Hospital, Baltimore, Md.

"Electroencephalographic Changes Brought to Light Under Pentothal Activation in Psychotic (Schizophrenic) Patients with Particular Reference to Changes Produced by Pharmacologic Agents" - Douglas Goldman, Long View State Hospital, Cincinnati, Ohio.

"Electrographic Depth Recordings from the Brains of Psychotics" - Stephen L. Sherwood, Illinois State Psychiatric Institute, Chicago, Ill.

"Some Findings in the Autonomic Nervous System in Schizophrenia" - Charles G. Ingram, Schizophrenia and Psychopharmacology Research Project, Ypsilanti State Hospital, Ypsilanti, Mich.

"Studies on Gamma-Aminobutyric and N-Acetyl Neuraminic Acid in Schizophrenia" - Eli Robins, Washington University School of Medicine, St. Louis, Mo.

"Metabolic Studies on Schizophrenic Children" - D. V. Siva Sankar, Eleanor Gold, Edward Phipps and D. Barbara Sankar, Children's Unit, Creedmoor State Hospital, Jamaica, N. Y.

"Biochemical Aspects of Indole Metabolism in Normal and Schizophrenic Subjects" - Herbert Sprince, Veterans Administration Hospital, Coatesville, Pa.

Session Chairman: Douglas Goldman
Long View State Hospital
Cincinnati, Ohio

2:00 P.M.-

"The Alleged Effect of Schizophrenic Serum on Rabbit Brain Catecholamines" - H. Weil-Malherbe, Herbert S. Posner, and F. N. Waldrop, Saint Elizabeth's Hospital, Washington, D. C.

"Brain Recordings with Schizophrenic Behavior: Some Metabolic Factors Responsible for Physiological Alterations" - Robert G. Heath, Tulane University School of Medicine, New Orleans, La.

"Steps toward the Discovery and Isolation of a Serum Factor in Schizophrenia" - Charles E. Frohman, Lafayette Clinic, Detroit, Mich.

"Fractionation Studies of Human Serum Factors Affecting Motor Activity in Trained Rats" - Benjamin E. Sanders, E. V. C. Smith, L. Flataker, and C. A. Winter, Merck Institute for Therapeutic Research, West Point, Pa.

"A Human Plasma Factor Inducing Behavioral and Electrophysiological Changes in Animals" - Robert B. Pennell, Blood Characterization and Preservation Laboratory of Protein Foundation, Inc., Jamaica Plains, Mass., and John R. Bergen, Worcester Foundation for Experimental Biology, Shrewsbury, Mass.

"A Review of Histologic and Histochemical Aspects (Biopsy and Post-Mortem Findings) in Schizophrenic Patients" - Leon Roizin, Psychiatric Institute, New York, N. Y.

"Reappraisal of Attitudes with Regard to Schizophrenia" - Henry Brill, Department of Mental Hygiene, State of New York, Albany, N. Y.

SECTION OF BIOLOGICAL AND MEDICAL SCIENCES

Charles Noback
Chairman

Preston L. Perlman
Vice-Chairman

NEW MEMBERS

Elected April 20, 1961

LIFE

Burkhard, Donald G., Ph.D., Physics. Professor, University of Colorado, Boulder, Colo.

Fernández-Guizzetti, G., M.A., Ethnolinguistics. Director of the Institute of Linguistics and Exolinguistics of the Catholic University of Santa Fe, Rosario De Santa Fe, Argentina.

Frohring, Paul R., B.S., Biochemicals & Pharmaceuticals. President, General Biochemicals, Inc., Chagrin Falls, Ohio.

SUSTAINING

Cacace, V. A., M.D., Surgery. Attending Surgeon, St. Vincents Hospital, Bridgeport, Conn.

Cary, Margaret M., A.B., Entomology. Research Fellow at Pennsylvania Academy of Natural Sciences, Philadelphia, Pa.

Cawley, John D., B.S., Organic Chemistry. Research Associate, Distillation Products Inc., Rochester, N.Y.

Coccia, S. Paul, M.D., Internal Medicine and Cardiology. Private Practice, Bound Brook, N.J.

Lebrun, Andre J., Ph.D., Epidemiology. Staff Epidemiologist, Tennessee Valley Authority, Signal Mountain, Tenn.

Murao, Narimasa, Chief Librarian, Fields of Atomic Energy Research. President of Library, Japan Atomic Energy Research Institute, Tookaimura Nakagun Ibarakiken, Japan.

ACTIVE

Agranat, Barnes, M.R.C.S., Medical Practice. Private Practice, North Johannesburg, South Africa.

Alavi, S. Hassan, D.O., Medicine. Professor of Ophthalmology, Teheran University, Teheran, Iran.

Albert, H. E. F., M.D., Surgery. Professor of Surgery, State University of Liege, Liege, Belgium.

Allen, Thomas H., M.D., Surgery. The University of Alabama Medical Center, Birmingham, Ala.

Alvarez-Carregal, E. Jose, Ph.D., Physiology. Research Associate, Huntington Memorial Hospital, Pasadena, Calif.

Amos, Richard E., Sc.D., Biological and Medical Sciences. Owner and Director, Arlington Laboratories, Columbus, Ohio.

Angle, Richard M., M.D., Internal Medicine. Private Practice, Santa Fe, N.Mex.

Armanious, Finley, M.B., Internal Medicine. Registrar Physician, Royal Infirmary, Sunderland, England.

Armstrong, Joseph J. B., M.Sc., Amino Acid Metabolism in Diseased States. University of Western Ontario, London, Ont., Canada.

Austin, George, M.D., Neurosurgery and Neurophysiology. Professor and Head of Division, University of Oregon Medical School, Portland, Ore.

Bair, William J., Ph.D., Radiation Biology. Manager, Pharmacology Operation, Hanford Atomic Products Operation, Richland, Wash.

Baker, D. G., Ph.D., Radiation Biology. Assistant Professor, C. H. Best Institute, Toronto, Ont., Canada.

Baker, Richard Kenneth, Ph.D., Psycopharmacology. Executive Director, Leeds-Dixon Laboratories Inc., New York, N.Y.

Bakerman, Howard A., B.S., Microbiological Assays. Chemist, National Institutes of Health, Bethesda, Md.

Baldinus, Joseph G., Ph.D., Drugs and Pharmaceuticals. Research Chemist, Smith, Kline and French Laboratories, Philadelphia, Pa.

Ballou, Clinton E., Ph.D., Carbohydrate and Phospholipid Chemistry. Associate Professor of Biochemistry, University of California, Berkeley, Calif.

Banks, William Louis Jr., M.S., Biochemistry and Physiology. Research Assistant, Rutgers University, New Brunswick, N.J.

Barber, G. Winston, Ph.D., Ophthalmic Biochemistry. Biochemist, Research Department, Wills Eye Hospital, Philadelphia, Pa.

Barbour, Benjamin H., M.D., Hypertension and Renal Diseases. Instructor Medicine, University Southern California, Los Angeles, Calif.

Barkulis, Sam Steven, M.D., Streptococcal Virulence. Director of Microbiological Research, CIBA Pharmaceutical Products Inc., Summit, N.J.

Barrett, Robert Emett, Ph.D., Acoustics. Assistant Professor of Physics, Providence College, Providence, R.I.

Binkerd, Evan Francis, B.S., Foods. Assistant Technical Director, Armour & Co., Chicago, Ill.

Black, Richard G., M.D., Neurophysiology. Research Associate, Department of Physiology, University of Toronto, Toronto, Ont., Canada.

Blake, Archie, Ph.D., Applied Mathematics. Engineer, Missile and Space Division, Raytheon Co., Bedford, Mass.

Blankenhorn, David H., M.D., Arterial Injury. Assistant Professor of Medicine, University of Southern California School of Medicine, Los Angeles, Calif.

Blasbalg, Herman, Dr.Eng., Statistical Communication Theory. Advisory Engineer, IBM, Baltimore, Md.

Bloom, Louis Richard, M.S., Physical Electronics. Laboratory Manager, General Telephone & Electronic Labs., Bayside, L.I., N.Y.

Blumberg, Richard Winston, M.D., Infectious Diseases. Professor and Chairman, Department of Pediatrics, Emory University School of Medicine, Atlanta, Ga.

Bonvicino, Guido Eros, Ph.D., Organic and Medical Chemistry. Research Chemist, Medicinal Chemistry Research Section, Lederle Laboratories, American Cyanamid Co. Pearl River, N.Y.

Boulanger, Wayne J., M.D., Cancer Research. Clinical Instructor in Surgery, Marquette University Tumor Clinic, Columbia Hospital, Milwaukee, Wis.

Bousquet, E. W., Ph.D., Synthetic Organic Compounds for Biological Allications Research Chemist, DuPont Experimental, Wilmington, Del.

Boutourline-Young, Harben, M.D., Physiology. Assistant Professor, Harvard University, Boston, Mass.

Bradley, John A., A.B., Nuclear Science. Consultant, The Brakeley Co., New York, N.Y.

Brancato, Leo J., M.S., Mechanical Engineering. Vice-President, Operations, Heli-Coil Corporation, Danbury, Conn.

Braun, Geza, Dr.Chem., Chemistry of Carbohydrates. Research Director, National Biochemical Corporation, Brooklyn, N.Y.

Braverman, J. B. S., D.Sc., Biochemistry. Professor of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

Bresler, Ann Esther K., Ph.D., Biochemistry. Senior Postdoctoral Fellow, Albert Einstein College of Medicine, New York, N.Y.

Bridges, Charles H., Ph.D., Veterinary Pathology. Professor and Head, Department of Veterinary Pathology, Texas A. & M. College, College Station, Texas.

Brien, Paul L. T., Biologic Animale. Professor, Université libre de Bruxelles, Brussels, Belgium.

Briggs, Jerome, M.A., Latin American Ethnology. Lecturer in Anthropology, Hunter College, New York, N.Y.

Bright, J. Russell, Ph.D., Inorganic Chemistry. Acting Dean, College of Liberal Arts, Wayne State University, Detroit, Mich.

Broadwell, James E., Ph.D., Fluid Mechanics. Senior Member of the Technical Staff, Space Technology Laboratories Inc., Pacific Palisades, Calif.

Brodsky, Isadore, M.D., Leukemia. Fellow from National Cancer Institute at Hospital of the University of Pennsylvania, Philadelphia, Pa.,

Bronsky, David, M.D., Endrocrinology. Assistant Professor of Medicine, University of Illinois, Chicago, Ill.

Brooks, Clyde, Ph.D., Arthritis. Doctor on Staff, Bryce Hospital, Tuscaloosa, Ala.

Brooks, Marion A., Ph.D., Insect Development and Microbiology. Assistant Professor, University of Minnesota, St. Paul, Minn.

Brooks, Sam C., Jr., Ph.D., Biochemist. Research Associate, Detroit Institute of Cancer Research, Detroit, Mich.

Brown, Alfred E., Ph.D., Chemistry. President, Harris Research Laboratories, Inc., Washington, D.C.

Brown, Alfred Seely, Ph.D., Physical Chemistry. Professor of Chemistry, Colgate University, Hamilton, N.Y.

Brown, F. Martin, Rhopalocera of the Americas. Head of Science Department Fountain Valley School, Colorado Springs, Colo.

Brown, Horace D., Ph.D. Medicinal Chemistry. Research Associate, Merck & Co., Inc., Rahway, N.J.

Brown, John B., Ph.D., Physical Chemistry. Associate Professor, Department of Chemistry, Denison University, Granville, Ohio.

Brown, W. Lynn, Ph.D., Effects of radiation on behavior. Professor of Psychology, The University of Texas, Austin, Texas.

Brown, William Everett, Ph.D., Microbiological Research. Head, Microbiological Development, The Squibb Institute for Medical Research, New Brunswick, N.J.

Bryan, Gordon H., Ph.D., Cardiology. Montana State University, Missoula, Mont.

Bryan, Hugh D., M.S., Pharmaceutical Product Development. Director, Pharmaceutical Product Development, Evansville, Ind.

Bryan, Loren Aldro, Ph.D., Chemical Research and Development. Acting Section Head, Great Lakes Carbon Corporation, Morton Grove, Ill.,

Buchsbaum, David A., Ph.D., Mathematics. Associate Professor of Mathematics, Brandeis University, Waltham, Mass.

Budenbom, H. T., E.E., Physics. Consultant, Curtiss Wright Electronics, East Paterson, N.J.

Bueche, Arthur M., Ph.D., Chemistry. Manager, Polymer and Interface Studies, General Electric Laboratory, Schenectady, N.Y.

Buess, Charles M., Ph.D., Chemistry. Associate Professor, University of Wichita, Wichita, Kan.

Buessem, Wilhelm R., Dr. Ing., Ceramics. Professor of Ceramic Technology, Pennsylvania State University, University Park, Pa.

Buhlman, Barbara North, B.S., Biochemistry. Student, Montclair State College, Montclair, N.J.

Bulmer, Joseph J., M.S.E., Reactor Physics. Reactor Physicist, Knolls Atomic Power Laboratory, Schenectady, N.Y.

Burckhalter, Joseph Harold, Ph.D., Steroid Hormone Relatives. Professor of Pharmaceutical Chemistry, The University of Michigan, Ann Arbor, Mich.

Burg, Stanley P., Ph.D., Plant Physiology. Assistant Professor of Physiology, University of Miami School of Medicine, Miami, Fla.

Burghardt, Stanley Ignatius, Ph.D., Physical Chemistry. Project Leader, Isomet Corporation, Palisades Park, N.J.

Burgyan, Aladar, Chem.Eng., Inorganic Colorants. Director of Color Research and Development, Ferro Corporation, Cleveland, Ohio.

Burke, Edmund Charles, Ph.D., Physical Metallurgy. Research, Lockheed Aircraft Corporation, Palo Alto, Calif.

Burke, Henry T., Ph.D., Organic Chemistry, Patent Chemist, Chas. Pfizer & Co., Inc., Brooklyn, N.Y.

Burkholder, Walter H., Ph.D., Phytopathogenic Bacteria. Professor Emeritus, Cornell University, Ithaca, N.Y.

Burnett, Leo Seth, Ph.D., Polymers. Technical Director, Food Machinery and Chemical Corporation, New York, N.Y.

Bush, Louise F., Ph.D., Zoology. Assistant Professor of Zoology, Drew University, Madison, N.J.

Butler, Edward B., Ph.D., Surface Chemistry. Senior Research Engineer, Pan American Petroleum Corporation, Tulsa, Okla.

Buzzell, Anne, Ph.D., Biophysics-Microbiology. Biophysicist, Walter Reed Army Medical Center, Frederick, Md.

Byler, William H., Ph.D., Luminescence. Vice-President, Phosphor & Screen Division, U.S. Radium Corporation, Morristown, N.J.

Byrne, Edward Vincent, M.S., Biology. Assistant Professor, St. John's University, Brooklyn, N.Y.

Byrne, John J., M.D., Surgery. Director, Boston City Hospital, Boston University School of Medicine, Boston, Mass.

Calva, Jose Baraquiel, Ch.E., Chemical Mechanical and Electrical. President, J.B. Calva and Co., Minneapolis, Minn.

Calvert, Robert, Ph.D., Head of Patent Section. The Borden Co., New York, N.Y.

Calvin, Allen D., Ph.D., Psychology. Director, Britannica Center for Studies in Learning and Motivation, Hollins College, Va.

Cameron, Harcourt, M.Sc., Geology. Professor, Acadia University, Wolfville, N.S., Canada.

Cann, John Rusweiler, Ph.D., Physiochemistry of macromolecules. Associate Professor, University of Colorado Medical Center, Denver, Colo.

Cannon, Helen L., M.S., Botanical prospecting and trace elements related to health. Geologist, U.S. Geological Survey, Denver, Colo.

Cannon, Peter, Ph.D., Surface & Solid-State Chemistry. Physical Chemist, General Electric Research Laboratories, Schenectady, N.Y.

Cantino, Edward C., Ph.D., Microbiology. Professor, Michigan State University, East Lansing, Mich.

Capinjola, John V., M.S., Chlorinated Organic Chemicals. Technical Director, Koppers Co., Inc., Wyandotte, Mich.

Carberry, James John, Dr.Eng., Chemical Engineering. Senior Research Engineer, E. I. du Pont de Nemours & Co., Wilmington, Del.

Carlin, Robert Burnell, Ph.D., Organic Chemistry. Becker Professor and Head, Carnegie Institute of Technology, Pittsburgh, Pa.

Carman, Katharine W., Ph.D., Geology. Consulting Geologist, Estes Park, Colo.

Carnahan, James E., Ph.D., Biochemistry. Research Supervisor in the Central Research Department, E. I. du Pont de Nemours & Co., Wilmington, Del.

Carpenter, Will D., Ph.D., Fat Metabolism. Research Biochemist, Research Department, Monsanto Chemical Co., St. Louis, Mo.

Carriere, Rita M., Ph.D., Histology. Instructor in Anatomy, State University of New York, Downstate Medical Center, Brooklyn, N.Y.

Carter, Mary Eddie, Ph.D., Carbohydrates and Proteins. Research Chemist, American Viscose Corp., Marcus Hook, Pa.

Casola, Armand Ralph, Ph.D., Medicinal Chemistry. Senior Research Chemist, Wallace & Tiernan Inc., Belleville, N.J.

Cason, James, Ph.D., Organic Chemistry. Professor, University of California, Berkeley, Calif.

Castermans, André, M.D., Experimental Surgery. Department of Surgery, University of Liege, Liege, Belgium.

Cech, Robert E., M.S., Metallurgy. Metallurgist, General Electric Research Laboratory, Schenectady, N.Y.

Chang, Shih Lu, Ph.D., Public Health Microbiology. Medical Director, U.S. Public Health Service, Cincinnati, Ohio.

Chanley, Jacob David, Ph.D., Chemistry. Research Associate, Mt. Sinai Hospital, New York, N.Y.

Cheraskin, Emanuel, D.M.D., Oral Medicine. Professor & Chairman, University of Alabama, Birmingham, Ala.

Connell, Thomas H. Jr., M.D., Cardiovascular Surgery. Associate Attending Surgeon, Bridgeport Hospital, Bridgeport, Conn.

Cotton, Frank Albert, Ph.D., Inorganic Chemistry. Professor of Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

Dalland, John L., Ph.D., Psychology. Associate Professor of Psychology, Wagner College, Staten Island, N.Y.

Dater, Eleanor E., A.B., Ornithology. Ramsey, N.J.

Davalos-Hurtado, Eusebio, M.D., Antropología Fisica. Director, Instituto Nacional de Antropología e Historia, Mexico, D.F., Mexico.

De l'Enfant-Jésus, M. Mother, Ph.D., Biochemistry. Assistant Professor of Chemistry, Marymount College, Tarrytown, N.Y.

De Lisle, Carol W., B.A., Microbiology. Microbiologist, E. R. Squibb and Sons Institute for Medical Research, New Brunswick, N.J.

Demner, Sigfrido, M.D., Chest Surgery and Cardiovascular Surgery. Associated Surgeon, Samaritan Hospital, Bogota, Colombia.

De Mora y Vaquerizo, Juan Miguel, Ph.D., History. Nuclear Energy, Space Ships, Author and Journalist, Scientific Books, Newspaper and Magazine Articles, Mexico, D.F., Mexico.

Desio, Ardito, Geology. Director, Institute of Geology, University of Milan, Milan, Italy.

Dow, James, B.S., Mathematics. Applied Research Laboratory Staff, Sylvania Electric Co., Needham, Mass.

Ebert, Andrew G., Ph.D., Pharmacology. Research Fellow, Purdue University, Lafayette, Ind.

Ehrensvärd, Gösta Carl Henrik, Ph.D., Biochemistry. Professor, Head of the Department of Chemistry, University of Lund, Lund, Sweden.

Eisenschiml, Ralph, Fungicides and Bactericides. Vice-President of Scientific Chemicals Inc., Chicago, Ill.

Elder, Alexander Taylor, Ph.D., Social and Preventive Medicine. Deputy Chief Medical Officer, Ministry of Health and Local Government, Belfast, Northern Ireland.

Evenson, Oscar L., M.A., Chemistry. Retired, Whittier, Calif.

Finch, William G. H., Prof.Eng.Lic., Physical Sciences. Consulting Engineer, U.S. Navy, Washington, D.C.

Finley, John K., M.Sc., Biological Science. Associate in Ophthalmology, University of Pennsylvania, Philadelphia, Pa.

Flickinger, Dale B., M.D., Medicine. Wound Healing, Great Plains Clinic, Minot, N. Dak.

Freedman, Jacob B., D.O., Medicine and Proctology. Private Practice. Bronx, N.Y.

Fuson, Roger Baker, Ph.D., Immunology and Bacteriology. Associate Director of Laboratory of Experimental Medicine, Montana Deaconess Hospital, Great Falls, Mo.

Gamble, Edward Watts III, M.D., Psychiatry. Staff Member, St. Albans Hospital, Radford, Va.

Giorgio, Patricia Mary, B.A., Biochemistry. Analytical Chemist for Schwarz Bioresearch, Inc., Mount Vernon, N.Y.

Grover, Milton M., Jr., M.D., Medicine. Radiologist, Benedictine Hospital, Kingston, N.Y.

Grove-Rasmussen, Morton, M.D., Blood Group Serology. Director, Blood Bank, Massachusetts General Hospital, Boston, Mass.

Haak, Fred A., Ph.D., Solid State Physical Electronics. Senior Staff Physicist, Hughes Research Labs., Malibu, Calif.

Hahn, Allen W., D.V.M., Cardiovascular Disease in domestic animals. Research Assistant, Department of Small Animal Surgery and Medicine, Auburn University, Auburn, Ala.

Halbrecht, G. I., M.D., Obstetrics and Gynecology. Associate Clinical Professor, Hebrew University Medical School, Jerusalem, Israel.

Halonen, Pentti Ilmari, M.D., Cardiology. Professor in Internal Medicine, University of Helsinki, Helsinki, Finland.

Harris, Alvin H., M.D., Homotransplantation. Resident in Surgery, University Hospitals of Cleveland, Cleveland, Ohio.

Haust, M. Daria, M.D., Medicine. Assistant Professor, Queen's University, Kingston, Ont., Canada.

Heatherman, Mary E., Ph.D., Microbiology. Consulting Bacteriologist, St. Joseph's Hospital, San Francisco, Calif.

Heinemann, Richard, B.S., Chemistry. Instructor in Physical and Analytical Chemistry, The College of Steubenville, Steubenville, Ohio.

Hendrickson, Adolph A., Ph.D., Legume Bacteria. Director of Research and Production, Nodogen Laboratories, The Albert Dickinson Co., Chicago, Ill.

Hernandez-Peon, Raul, M.D., Neurophysiology. Director, Brain Research Unit, Mexican Public Health Service, Mexico D.F., Mexico.

Herne, Richard Gustav, Chand.med., Oncology. Chief Oncologist, Ayerst Research Laboratories, Montreal, Que., Canada.

Hillman, Robert B., D.V.M., Veterinary Medicine. N.I.H. Research Fellow, New York State Veterinary College, Ithaca, N.Y.

Hoffman, Abraham C., D.Phil., Anthropology. Director of the National Museum, Bloemfontein, South Africa.

Holder, Thomas Martin, M.D., Pediatric Surgery. Chairman, Department of Surgery, The Children's Mercy Hospital, Kansas City, Mo.

Hsu, Irene, M.D., Cardiology. Assistant Professor of Medicine, George Washington University Medical School, Washington, D.C.

Hsu, Kwan, Ph.D., Biophysics. Assistant Chief for Biophysics, Veterans Administration Hospital, Indianapolis, Ind.

Husain, Muhammad Afzal, D.Sc., Zoology. Retired, Lahore, Pakistan.

Karageorgis, Basile, M.D., Biological and Medical Sciences. Chief Surgeon, Department of Surgery, General Hospital Sainte Olga, Athens, Greece.

Keeble, Stanley Arthur, M.R.C.V.S., Veterinary Science. Head of Veterinary Virus Research Unit, Glaxo Laboratories Ltd., Greenford, Middlesex, England.

Kirk, David L., Ph.D., Biochemistry. Research Biochemist, Colgate-Palmolive Co., New Brunswick, N.J.

Klein, Johanna C., M.D., Biological and Medical Sciences. Tissue Culture Unit, Communicable Disease Center, Atlanta, Ga.

Knapp, Pearl Gilliland, Ph.D., Psychology. Chief Psychologist, Cedars of Lebanon Medical Center, Los Angeles, Calif.

Landa, Lloyd Sherwin, D.D.S., Prosthetic Dentistry. Assistant to the Director, New York University College of Dentistry, New York, N.Y.

Lepp, Albert, Ph.D., Endocrinology. Supervisory Biochemist, Veterans Administration Hospital, Indianapolis, Ind.

Levene, Howard, Ph.D., Mathematical Statistics. Professor of Mathematical Statistics, Columbia University, New York. N.Y.

Liebelt, Robert A., Ph.D., Experimental Biology. Professor and Chairman of Anatomy, Baylor University College of Medicine, Houston, Tex.

Linder, Leon, M.D., Medicine and Anesthesiology. Medical Director, Prospect Hospital, Bronx, N.Y.

Lish, Paul M., Ph.D., Pharmacology. Section Leader, Mead Johnson Research Center, Evansville, Ind.

MacCarthy, Dermond De La C., M.D., Pediatrics. Consultant Pediatrician, Oxford Regional Hospital Board, Aylesbury, England.

MacRae, Donald Fraser, B.A., Applied Physics. Manager, Appliance, Executive Vice-President, Campbell Electric Ltd., Kitchener, Ont., Canada.

McGinnis, James, Ph.D., Nutrition and Biochemistry. Chairman, Department of Poultry Science, Washington State University, Pullman, Wash.

McMahon, Edward F., M.D., Cardiovascular Disorders. Private Practice, Brooklyn, N.Y.

Mabayje, John Oluyemi, M.R.C.P., Internal Medicine. Specialist Physician, Federal Ministry of Health, Lagos, Nigera.

Maggs, Robert L., M.D., Medicine. General Surgeon, Lenox Hill Hospital, New York, N.Y.

Maingot, Rodney, F.R.C.S., Abdominal Surgery. Consulting Surgeon, Royal Free Hospital, London, England.

Manson, John Alexander, Ph.D., Physical Chemistry. Section Head, Chemical Research, Central Research Laboratories, Air Reduction Co. Inc., Murray Hill, N.J.

Mathé, Georges, M.D., Leukemia. Professor, Faculty of Medicine, Paris, France.

Mathes, W. T. Jr., M.D., Medicine. Private Practice, Johnson City, Tenn.

Menke, John Frederick, M.D., Cancer Research. Practicing Surgeon, Private Practice, Sacramento, Calif.

Mennie, Alexander Thomson, M.B., Clinical Medicine. Medical Practitioner, London, England.

Milder, Jack W., M.D., Cancer Chemotherapy. Administrator, Grants for Research on the Therapy of Cancer, American Cancer Society, Inc., New York, N.Y.

Mima, Kiyoshi, M.D., Research and Operation of Stomach-Cancer. Dean and President of Kyoto Kuramaguchi Hospital of Japanese Welfare Government, Kyoto, Japan.

Mitchell, Leonard Ross, M.D., Psychiatry. Private Practice, Vista, Calif.

Moriarity, Andrew J., M.D., Pharmaceutical Research. Medical Director, Smith Kline and French Laboratories, Montreal, Que., Canada.

Muller, Sigfrid A., M.D., Dermatology. Clinical Dermatologist and Private Practice, Whittier, Calif.

Murray, Roger Cawley, M.D., General Surgery. Private Practice, St. Paul, Minn.

O'Donovan, Charles, M.D., Pediatrics. Private Practice, Baltimore, Md.

Ogata, Tomio, M.D., Serology. Professor of Serology, Faculty of Medicine, University of Tokyo, Hongo, Tokyo.

O'Heeron, Michael Kinney, M.D., Medicine Urology. Clinical Professor, Baylor University, Houston, Texas.

Orne, Martin T., Ph.D., Special States of Consciousness. Senior Research Psychiatrist, Massachusetts Mental Health Center, Boston, Mass.

Otis, Arthur S., Ph.D., Psychology. Retired, St. Petersburg, Fla.

Panasewicz, Józef, M.D., Hematological Physiopathology. Institute of Hematology, Warsaw, Poland.

Peskin, James C., Ph.D., Cell Physiology. Assistant Professor, Institute of Optics, University of Rochester, Rochester, N.Y.

Politoske, E. J., M.D., Neurosurgery. Private Practice, Santa Ana, Calif.

Quintero, Jorge A., M.D., Internal Medicine. Professor of Medicine, Zulia University, Maracaibo, Venezuela.

Rao, Ravindra Pratap, Ph.D. Synthetic Organic Chemistry. Assistant Professor, Department of Chemistry, University of Gorakhpur, Gorakhpur, India.

Rauen, Hermann, Dr.Rer.Nat., Biochemistry. Professor, Physiologisch-Chemisches Institut der Universität Münster/Westf., Münster/Westf., Germany.

Rehberg, Poul K. B., Ph.D., Physiology. Professor, Zoophysiology, University of Copenhagen, Copenhagen, Denmark.

Ringbom, Anders, Dr. of Technology, Chemistry. Professor of Analytical and Inorganic Chemistry, Abo Academy, Abo, Finland.

Robbins, W. Rei., Ph.D., Plant Physiology. Professor, Rutgers, The State University, New Brunswick, N.J.

Russek, Henry I., M.D., Cardiovascular Disea Consultant in Cardiovascular Disease, U.S. Public Health Service Hospita. Staten Island, N.Y.

Ryan, D. E., Ph.D., Analytical and Inorganic Chemistry. Associate Professor, Dalhousie University, Halifax, N.S., Canada.

Saenz, Abelardo, M.D., Biologie. Professeur, Institut Pasteur, Paris, France.

Saks, Norman M., M.A., Cell Physiology. Teacher, Lafayette High School, Brooklyn, N.Y.,

Sanders, Curtis Remmel, B.S., Mathematical Models of Biological Systems. Applied Science Representative, International Business Machines Corp., Santa Monica, Calif.

Sandri-White, Alex, Dr.Ed., General Science. Writer, Director of Publishing Firm, Central Valley, N.Y.

Santella, Paul J. Jr., B.A., Pharmacology and Biochemistry. Jr. Pharmacologist, Smith Kline & French Laboratories, Philadelphia, Pa.

Santorini, P., Dr.Sc.Phys., Electronics and Engineering. Director Laboratory, The National Technical University, Athens, Greece.

Schumer, William, M.D., General Surgery. Surgical Educational Coordinator, Mount Sinai Hospital, Chicago, Ill.

Shaw, Malcolm E., B.S., Management Education. Visiting Lecturer, New York State School of Industrial and Labor Relations, Malcolm E. Shaw Associates, Mountain Lakes, N.J.

Skurska, Zofia, Dr.Ph., Microbiology. Chief Assistant of the Virology Department, Polish Academy of Sciences, Wroclaw, Poland.

Smith, Alfred A., M.D., Medical Research. Research Fellow, Department of Psychiatry, New York University Medical Center, New York, N.Y.

Snodgrass, Samuel R., M.D., Medicine. Professor of Neurological Surgery, The University of Texas Medical Branch, Galveston, Texas.

Stern, Arthur L., M.R.S.H., Hospital Administration. Administrator, Kings Highway Hospital, Brooklyn N.Y.

Stitt, Pauline G., M.D., Home Care Service. Associate Professor of Preventive Medicine and Pediatrics, Massachusetts Memorial Hospitals, Boston, Mass.

Sutton, Carl H., M.D., Neurosurgery. Research Fellow, Peter Bent Brigham Hospital and Harvard University Medical School, Boston, Mass.

Templeton, John Y., III, M.D., Surgery. Clinical Professor Surgery, Jefferson Medical College of Philadelphia, Philadelphia, Pa.

Teorell, Torsten, M.D., General Physiology. Professor and Chairman of the Institute of Physiology and Medical Biophysics, University of Uppsala, Uppsala, Sweden.

Terrill, Robert L., B.S., Vegetable oils and proteins. Vice-President, Research and Development, Spencer Kellogg and Sons, Inc., Buffalo, N.Y.

Tice, David A., M.D., Medicine. Instructor in Surgery, New York University College of Medicine, New York, N. Y.

Traub, Sidney P., M.D., Diagnostic Radiology. Associate Professor of Radiology, University of Saskatchewan College of Medicine, Saskatoon, Sask, Canada.

Van Orden, Lucas S., M.D., Neurophysiology. Fellow in Anatomy, Yale University School of Medicine, New Haven, Conn.

Van Oss, Carel Jan, D.Sc., Physical Biochemistry. Director, Laboratory of Physical Biochemmstry, National Veterinary College, Alfort (Seine) France.

Vejerano, Alberto, M.D., General and Thoracic Surgery. Head Surgeon, Fundacion Shaio, Bogota, Colombia.

Velasco, Antonio Gomez, M.D., Pathology. Training in Pathology, Sanatorio Espanol, Mexico, D.F., Mexico.

Warren, James C., M.D., Steroid Chemistry. Assistant Professor, Department of Obstetrics & Gynecology, University of Kansas Medical Center, Kansas City, Kan.

Weatherall, Miles, B.Sc., Pharmacology. Professor of Pharmacology, London Hospital Medical College, University of London, London, England.

Weber, Clifford E., Ph.D., Nuclear Engineering. Manager, Fuel & Materials Department, Atomics International, Canoga Park, Calif.

Weissbecker, Ludwig, M.D., Endocrinology. Director 2, Medical Clinic Karlsruhe, Karlsruhe, Germany.

Wetzel Frederick E., M.D., Psychosomatic Medicine. Internist, State Mental Hospital, Norwalk, Calif.

Williams, Gordon F., M.D., Biological & Medical Sciences. Associate Clinical Professor of Pediatrics, Stanford University School of Medicine, Stanford, Calif.

Winkler, Carl A., Ph.D., Physical Chemistry. Chairman, Department of Chemistry, McGill University, Montreal, Que., Canada.

Wolpe, Joseph, M.D., Neurosis. Research Professor of Psychiatry, University of Virginia Hospital, Charlottesville, Va.

Wylie, David W., Ph.D., Pharmacology. Assistant Director, New Product Development, Sterling Drug Inc., New York, N. Y.

Yoshishita, Tetsuo, M.D., Biological and Medical Sciences. Assistant, Osaka University Hospital, Osaka, Japan.

STUDENT

Chiappetta, Vincent J., M.S., Biological and Medical Sciences. Research Biologist, Lederle Laboratories, Pearl River, N. Y.

Cordts, Richard H. Jr., B.S., Animal Nutrition. Research Fellow, Rutgers, The State University, New Brunswick, N. J.

Com, Joyce-Ruth, A.B., Anthropology and Psychology. Student, Hunter College, Bronx, N. Y.

Coyne, Theresa Anne, B.S., Radiation Biology. Student, Marymount College, Tarrytown, N. Y.

Krohn, Herbert Fried, B.A., Experimental Biology & Medicine. Student, New York University, New York, N. Y.

Srinivasan, B. Dobli, A.B., Cell Biology. Graduate Student, Columbia University, New York, N. Y.